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We are asked occasionally for particulars of the mining regulations in Siam. The latest enactments were made in 1901. As copies of the full text are unobtainable in this country, we give herewith the main provisions of the Act. For this information we are indebted to the Siamese Minister in London.

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EDITORIAL

THE payment of a cash dividend of 50% by Minerals Separation, Limited, marks the beginning of what we hope may be a long continued financial prosperity. The dividend will be particularly gratifying to the shareholders who have sat tight during the twelve years of metallurgical and legal campaigns.

IN spite of adverse conditions, the students of the Imperial College of Science & Technology manage to maintain the publication of their journal, the *Phœnix*. In the current issue there appears an interesting article on the early history of gold mining in Sumatra, which, by favour of the editor, we reproduce in our Mining Digest.

WAR continually stimulates a search for substitutes. Two articles much to the front nowadays, margarine and beet sugar, were introduced in this way by the French. The cultivation of beet was developed during the Napoleonic wars, because we had cut off the supply of cane sugar from the West Indies. Margarine was invented during the Franco-Prussian war of 1870-1 owing to the shortness of dairy produce.

EXCITEMENT prevailed for the proverbial nine days at Ramsey, in Huntingdon, during Christmas time, owing to an oil-flow being discovered in a water well. The fact that the oil resembled kerosene and was fit for burning in lamps led the experts to look for a leaking storage tank rather than a natural oil seepage, and their search was soon rewarded. The disappointment of the hopeful gentlemen who had "struck oil" is all the more exasperating seeing that Ramsey is in a neighbourhood where petroleum might be expected. At Ely, over the Cambridge border, genuine seepages have occurred, as they have also in the neighbourhood of King's Lynn in West Norfolk. Moreover the Kimmeridge oil-shales are to be found somewhere underneath.

THE proposal made by Mr. Stephen J. Lett that independent engineers should be appointed to audit those sections of a company's report relating to the mining position is not entirely a new one. It is true, as Mr. Lett contends, that directors have not always presented the consulting engineer's or mine manager's views in the way that either the shareholders or the engineer would like. To remedy this state of things it was proposed some years ago that the consulting engineer should be elected by the shareholders in general meeting just as the financial auditors are. Such a course would have the advantage of not establishing a new source of expense to the companies, and it would avoid possible friction and unpleasantness between two sets of members of the same profession, the consulting engineers and the engineering auditors, a friction which would surely take place if Mr. Lett's proposal were adopted. Our view of the subject, however, is that there is no extensive necessity for an engineering auditor, and that the relations of consulting engineers and boards of directors are generally as satisfactory as can ever be possible. For one thing the status of the professional mining engineer is now much stronger than it was say twenty years ago; and for another the critics on the daily and weekly press are better informed and of more independent spirit than formerly. It is therefore seldom that any glaring misstatement is possible. We have read practically every yearly report of the mining companies known in London issued during the past eight years, and we consider that their standard of fairness is high. There have been sufficient exceptions to justify an occasional growl from shareholders, and it is well for candid critics like Mr. Lett to utter a word of protest and warning from time to time. These public criticisms will have more beneficial effect than the provision of additional company machinery.

IN this issue we commence the publication of a series of articles by Mr. W. H. Goodchild, elaborating several new points bearing on the origin and constitution of ore-bodies. These articles will provide hard reading to most people, and indeed many may say that they are suitable rather for a learned society or for a journal dealing with advanced geology, than for a Magazine which aims at giving a general review of mining and metallurgical operations and interesting the business man in the main technological principles. Nevertheless we make no apology for granting the articles the hospitality of our pages, for their publication gives us the opportunity for impressing once more on the mining community the necessity for applying every advance in scientific knowledge to the domain of mining. The average commercial man and director of mining companies too seldom gives due credit to the technical man at the mine, and in fact often fails to appreciate the necessity for securing the best engineering and scientific assistance. The publication of these articles may serve to show that our most up-to-date geologists are thinking-out explanations of the occurrences of ore that will help in prospecting and in following surface indications. To practised geologists the article will show that chemical and metallurgical experience will help in solving the problems of ore deposits to a greater degree than microscopic study. As we have said, the articles do not provide easy reading. We had intended to publish in this issue an editorial sketching the author's views in a way easily comprehensible to beginners, but as the present instalment of the article is in the nature of an introduction, and as the important conclusions will be given in later issues, we postpone our explanatory article.

ON another page, Mr. R. Gilman Brown replies to our remarks in the December issue relating to the definition of "ore reserves." He points out that the narrow application of this term to "ore blocked-out," as suggested by us, is not fair in the case of big pyritic masses, for here, by systematic boring and by deductions from geological examination, reliable data can be obtained on which to estimate ore in place. We hope that other engineers will join in this discussion. Another matter requires mention. Though our Editorial last month was intended solely as a disquisition on definitions, we regret to find that in some quarters it has been interpreted as an attack on the Kyshtim engineers and even as a veiled insinuation that the ore is not there. Such a supposition is, of course, absurd, and the incident only shows the danger of illustrating a general principle by a specific instance. As a matter of fact, we, together with every one who knows them, have the greatest confidence in the engineers and geologists connected with the Kyshtim Corporation.

The Register of Old Students of the Royal School of Mines.

The Royal School of Mines has passed through several crises in its career, and certain interested parties are still desirous of making a meal of it for their own strengthening. Many have been the calls among the leaders of the old students for the closer combination of the friends and supporters of the School. The faithful have rallied, but the total response is not yet sufficient to be called sufficiently representative, and this absence of complete solidarity may leave the School weak against the University raiders. The fight for the existence of the School as a separate entity is not, however, the sole object sought by these calls, for the personal league of fellowship can effect much wider objects, namely, the welfare of the individual and the appreciation throughout the world of the value of the training received at the School.

For many years the old School ties were preserved by nothing more than an annual dinner. The poverty of ideas which characterized such a state of things was fully recognized later, and in 1913 a real Association of Old Students was formed. The present position is well presented by the official statement of the objects of the Association: "1) to endeavour to maintain the identity of the Royal School of Mines and its distinctive diploma; 2) to foster the comradeship, to advance the interests, and to present the views of Royal School of Mines men; and 3) to assist any of its members in whatever manner may be deemed possible." It is obvious that little or nothing can be done in any of these directions unless a reasonably complete and accurate Register of old students is prepared, and established on a permanent basis, whereby corrections and additions can be made currently. The committee of the Association has already done much in the collection of information for such a Register, but the getting into contact with, and the extraction of replies from, the old students is extremely difficult, particularly at present when so many of the old students are away from their regular professional employments. Success attends the efforts of the committee up to a certain point, but after that the problem is as troublesome as the raising of the percentage of recovery at a Cornish tin mine. The committee, seeing the necessity for a strenuous campaign, decided that the work of collecting the records should be delegated to one individual, and they were fortunate in persuading Mr. Ernest B. Lighthill to undertake it. At the present time he is actively circularizing those who have not yet replied, he is searching for the addresses of those who cannot at present be found, and in many other ways seeking for those who have not yet responded. By much research he has obtained the names of 1,600 old students, and from one source and another the addresses, more or less recent, of 1,200 of these have been secured. It is probable that the 1,600 represents not more than 75% of the total number.

The first circulars were sent out about eight months ago, and a reminder followed toward the end of 1917. Up to the present time, about 500 old students have replied, sending their records, and 150 of the circulars have been returned through the dead letter office. Mr. Lighthill and the committee feel that unless a much better result is obtained the purpose of the Register will not be achieved. In fact, they look to a Register containing at least 1,000 names. We take this opportunity of urging old students who have not yet replied to send in their records without delay, and also of inviting those who are not in contact with the committee to write for the necessary forms to Mr. Lighthill, c/o the Institution of Mining and Metallurgy, 1, Finsbury Circus, London, E.C.

The information required by the committee, and to be incorporated in the Register, is as follows: Name, present address, permanent address, school, period and date at the Royal School of Mines, subject in which the associateship was taken, membership of societies, university degrees, military decorations, appointments held, papers or books written. It is particularly desired that full details shall be given of each old student's war record, not only to gratify the pride of the profession, but also to help the juniors to get back to their profession when the war is over. We have quoted one of the objects of the Association as being "to assist any of its members in whatever manner may be deemed possible." This includes both helping the old students to appointments and in case of financial embarrassment the granting of some suitable pecuniary assistance. When the war is over, the Association will admirably perform the functions of an agency for introduction among engineers and between engineers and boards of directors, so that those who have fought for their country shall not find themselves obliged to drift into other occupations. As regards pecuniary help, it cannot be doubted that many who are now in the Army have made such sacrifices as to leave themselves short of funds and render themselves unable to meet some of their obligations. We may remind old students who are in this predicament that the committee is even now ready to consider their cases. In fact, we know that help has already been granted in this way, though of course the names of such beneficiaries are not divulged.

The Register when published will form a bulky volume, far larger than the first edition which appeared in 1896. That book was, and still is to those who are lucky enough to possess a copy, one of the most entrancing of all compilations, for it gave a history of the Royal College of Science and the Royal School of Mines, with portraits and biographies of the many eminent scientists who have held professorships at the two Schools, as well as details of the records of as many of the old students as could be traced or induced to give the necessary particulars. To publish a record of his achievements is each man's duty to his alma mater, to his profession, and to himself. There is no room for false modesty when other people are concerned. We have ourselves recently adopted the plan of always quoting the degrees and memberships of societies belonging to the authors of articles that appear in our pages. Moreover, in the City the advertising of a degree or Associateship of the School of Mines on the part of the engineer is of indirect but obvious benefit of the financial house that employs him. From all these points of view we trust that no old student will allow either his modesty or his indifference to stand in the way of the production of an adequately representative Register such as is desired by the committee of the Association of Old Students. Before closing this appeal to the Old Students we wish to express our gratification that the committee and Mr. Lighthill have done so well already. We have some experience of this class of work, and have good grounds for considering that to obtain 500 successes out of 1,600 is distinctly satisfactory. Even if no more replies were received we would strongly encourage the committee to go forward with publication. Those 500 are active and helpful men, and it is due to them that their records should be published. To the laggards and undecided we would say that the absence of their names from the published Register may possibly prove an unfortunate handicap.

The Generation of Power.

On a number of occasions recently we have discussed a problem now confronting industrial England, the economical production of power and heat, notably in the issue of March last when we reviewed our fuel and water resources, the various ways of utilizing them for the generation of power, and the relative merits of different systems of production and distribution. These problems have recently engaged the attention of a committee of practical men appointed by the Minister of Reconstruction. This Committee is officially entitled the "Coal Conservation Sub-Committee," and it includes representatives of users such as railways and cotton-spinners, a scientist who has specialized on fuels, a coal engineer, and electrical engineers. Their interim report, issued at Christmas, indicates the main line of their recommendations, namely, that electric power distribution will have to be adopted on a universal system, and that the policy will have to be national in character. This guiding principle having been established without gainsay, the filling-in of the details will present no difficulties to a Government Board consisting of business and technical men. As an ounce of fact will carry more conviction to the layman than a pound of scientific argument, the most impressive sentence in the present report is that which states that, in the factories built for the production of munitions during the war, 95% of the machinery is driven by electricity. As regards the source of the power to be produced on a gigantic scale, there is no other alternative to the employment of coal, for in Great Britain there is no petroleum or natural gas; in England the water-catchment areas are small and are required for providing water for town use, though why the water in passing from the collecting to the distributing reservoirs should not be made to do work is not quite clear; even in Scotland and Ireland the available supply of water power is quite inadequate for even a fraction of the industrial requirements of the British Isles. The main manufactures have in the past grouped themselves round the coalfields, and it is there that the generation of power on a large scale must be undertaken. The Committee recommends the establishment of sixteen centres of power-production throughout the country. These great stations are not to be in or adjacent to any town, and their exact position will be determined with regard to proximity to collieries, water-supply, and means of transport. The advantages of stations of this character are manifold. In the first place the hauling of coal along the railways will be well nigh abolished. Eventually it will be possible to apply electricity for domestic heating and other purposes, while the opportunities provided for the electro-chemist and electro-metallurgist will be obvious and gladly accepted. The cost of generation of current will be enormously reduced by the use of big machines each ten to twenty times the size of those at present employed, and capable of producing 20,000 or even 50,000 horse power. The placing of the generating stations in the coalfields will make it possible to mine coal that is at present not worth raising owing to its poor quality, a modification of conditions already demonstrated at the collieries at which the power houses have been electrified. The Committee draws attention to the many reasons why the uses of electric power and light have developed slowly in this country. The chief reason has been the relegation of the undertakings to restricted private enterprise and to small local bodies, each being given limited rights and areas, and, we may add, each taking a delight in passing on the pin-pricks to their customers. Thus in London there are twenty-nine electric generating stations, all independent and some antagonistic. Of the more recent installations those on comparatively large scales have been erected for the electrification of the railways, but even here the largest individual station has a capacity of only 63,000 electrical horse-power, while the average is only 5,000 e.h.p. Throughout Great Britain there are over 600 undertakings for the supply of electricity. Among all the different districts, Tyneside alone has inaugurated a systematic method of distribution commendable by the Committee, and here it has been possible to reduce the average charge to ½d. per kilowatt-hour. The Committee does not prognosticate the probable figure at which current would be supplied when their scheme has come to fruition, but we may take it that the price should be half that charged at Tyneside. It is estimated that at the present time 120 million tons of coal is burnt in this country every year for the production of power. By means of universal electrification, nearly one half of this coal should be saved, and if it were applied to the expansion of our industries, the power resources of the country would be enormously expanded. As regards the method of burning the coal for the generation of power, the Committee look to the steam engine as the mainstay, and in reference to the gasification of the coal and the extraction of light and heavy fuel oils, other coal tar products, and sulphate of ammonia, the Committee merely state that this should be done where it is proved economical to do so. The final problem in connection with this great project is in relation to the vested interests already established by the Government. A vast amount of public and private capital has been sunk in the electrical works already established, and some arrangement will have to be made to utilize the installations under the new scheme, or to grant some sort of financial compensation. That the installations already at work are not commercially perfect is not necessarily due to any fault of those who are responsible for them. Every electrical engineer is fully acquainted with the obstacles that have been put in his path by officialism and parochialism, by people in authority who know nothing about the matters in hand. Nor are manufacturers and other users of power free from blame for the slowness of advance in methods of power production. That Lancashire and Yorkshire are still covered with a mantle of smoke shows that national action is necessary in order to bring those responsible for the expenditure of capital for improvements to a more reasonable frame of mind. The members of the Committee are to be thanked for the efforts they are making to secure not only a greater efficiency in power production but a cleaner and healthier world for the workers.

The Institution of Civil Engineers.

On January 2 the Institution of Civil Engineers celebrated the hundredth anniversary of its first meeting. The date should not be allowed to pass by without some reference to the foundation of the premier engineering society of the world. There had been societies and clubs among the engineers before those days, but they were of social character rather than professional, and the talking of "shop" had not been encouraged at their meetings. In contradistinction the Institution of Civil Engineers was founded expressly for the object of extending and spreading engineering knowledge. The initiative came from H. R. Palmer, one of Telford's assistants, and he and seven others, two Maudslays, Field, Lethbridge, Jones, Collinge, and Ashwell, constituted the first official meeting in the early days of 1818. Two years afterward these pioneers had the good fortune to secure Telford as their president, and the still greater fortune to find that he put his whole soul into it and that he was willing to hold the post for fifteen years. Under his guidance the society went ahead so strongly that in 1828 it became possible to secure a Royal Charter of incorporation. The early meetings had been held at coffee houses and taverns in the City, but under Telford's auspices rooms were taken in Buckingham Street, Adelphi, close to where Charing Cross station now stands. In 1834 removal was made to a small house in Cannon Row, by Westminster Bridge, and again in a few years to Great George Street. A handsome building was erected on the latter site in 1865, and this was reconstructed and enlarged in 1894. The spread of Government departments in Westminster engulfed the Civils' property eight years ago, and a removal was made to a new home, specially designed for their modern requirements, on the other side of the way, nearer St. James' Park. A systematic method of publishing the transactions at the meetings was not adopted until 1836. Since then the series has been continuous and unbroken, and everyone knows the bulky volumes, produced in first-class style, and edited with rare ability. Early in its career the Institution saw the advisability of doing something more for the civil engineer than reading and discussing papers. It was soon able, by careful selection of entrances, to raise the status of the profession, and to give some guarantee of the capability and dependability of its members. In later years the council has gone still further, and has indicated the lines on which young engineers should base their courses of study and education. At the present time, admission to the ranks is as jealously guarded by examination and by requirements of training and experience as in the cases of medicine and the bar. We salute the mother of engineering societies on the centenary of her birth.

The Iron Pigments.

During the last few months we have had numerous inquiries relating to the pigments formed from iron compounds, either pure or naturally admixed with earthy materials. The bright reds and deep purples of pure ferric oxide are now being sought as substitutes for the more expensive, and almost unobtainable, compounds of mercury, antimony, and lead, known as vermilion and red lead. Similarly, the yellows and oranges associated with chromium, cadmium, and arsenic are giving place to the more humble ochres and sienas, which are clays coloured with hydroxides of iron. Nor is the scarcity confined to the pigments in which mineral matter gives the colour, for the supply of eosin lakes, known in the trade as vermilionettes, is also scanty. For the benefit of non-technical readers we may say that a "lake" consists of an organic colouring matter fixed on a mineral base. The question of cost and scarcity is aggravated by the fact that we have depended in the past on Germany for a large part of our supply of high-class pigments.

Owing to the many inquiries that we have received it is opportune to give an outline of the application of iron compounds as pigments. At the outset it may be said that the red iron compounds possess all the characteristics desirable in a pigment except supreme beauty. They are attacked by acids with difficulty, nor by other corrosive compounds occurring in unclean atmospheres. They mix well with other pigments without any inter-reaction. In fact they are the most permanent of all pigments. In addition their colouring power is intense, and a very small proportion will give a brilliant tint to a paint. The hydrated oxide colours, such as ochre and siena, are almost equally unaffected by atmospheric conditions or by admixture with other pigments, but their brightness and strength are seldom as pronounced as those of the red iron compounds. The iron pigments have the additional advantage of being non-poisonous, though this characteristic is of course not an advantage in the manufacture of anti-fouling compositions for ships and other structures exposed to the attack of animal life of various grades. As regards the red ferric oxide pigments, these are sometimes made by grinding and levigating hematite. As a rule the colour obtained is dark. Much brighter hues can be obtained by strongly heating ferrous sulphate. Originally this heating of ferrous sulphate was applied for the production of sulphuric acid, and the possibility of making bright red pigments from precipitated iron oxide was thus discovered. Nowadays the roasting of ferrous sulphate is undertaken specially for the production of pigments, and the escaping acid is in the nature of a by-product. The sulphate now used for this purpose is obtained from the waste liquors of various chemical and metallurgical processes, and the process of extraction is different. As an example of the method we may quote the cases of tinning and galvanizing, where the iron sheets are first treated by acid in order to remove all trace of rust. The sulphate thus formed used to be sent down the drains until the local authorities stopped it. By force of circumstances the manufacturers thus became provided with a useful source of income. Another example is provided by copper metallurgy. When sulphate of copper solutions coming from the pyrite roasting floors or from the residues of pyrite burners at the sulphuric acid plant are treated with scrap iron for the precipitation of copper, the iron goes into solution as sulphate. In recovering the iron from these waste liquors it is usual to precipitate it as oxide by the addition of an alkali such as lime, instead of by crystallizing and roasting. Under these circumstances some amount of lime will be precipitated as sulphate, and the resulting pigment will be correspondingly lighter in colour. The production of the grade of colour required is effected by regulating the degree of calcination of the ferric oxide. If the oxide is lightly burnt, a colour of the Venetian red type, orange-red to scarlet, is obtained. Stronger calcination introduces a purple tint characteristic of Indian red. A number of anhydrous iron pigments are also made by calcining ochres and sienas, and as the iron contents of these substances are low the colour is accordingly lighter.

The yellow, orange, and brownish yellow iron pigments used in the industries and arts are obtained from certain ferruginous clays known as ochres and sienas, containing usually free silica in addition. The ochres owe their colour to hydrated ferric oxide, $Fe_2(OH)_6$, that is, limonite. The sienas are darker in colour owing to the presence of oxide of manganese. When the manganese content increases, the colour becomes brown, and the pigment is then known as umber. These substances are found as pockety deposits associated with sedimentary rocks of a variety of geological ages. Some of the best qualities are found in the Oxford clay of the Jurassic period. The laterites may be considered theoretically to belong to this class of material, though the colour manufacturer would hardly agree to the proposition. Ochres and sienas are valued, not alone for their colour but according also to the other earthy mineral entering into their composition, and as to their relative transparency or opacity. In preparing them for use, they are ground and levigated in much the same way as china-clay, and the gritty and harsh constituents removed. The composition of the raw ochres varies widely, not only in the silicious content, which may sometimes be as much as 60%, but also by the presence of barite in large quantities. The constitution of the prepared pigment often differs widely from that of the raw material owing to the removal of certain constituents during levigation. The sienas are of much higher grade than ochres, and require little preparation for use as pigments. The iron content is generally over 60%, and the manganese content is about 2%. In the commercial umbers, the manganese content averages 10% and the iron over 30%, and as little preparation is necessary as in the case of the sienas. In deciding the value of ochre, siena, and umber, the economic conditions have strong influence. The deposits are plentiful and wide spread, but high quality and proximity to a ready market are prime necessities. Now that we are confronted with a scarcity of other and more expensive pigments, the iron compounds are experiencing a greater demand, and deposits of lower quality and at a greater distance from the markets may have their chance.

REVIEW OF MINING

Introductory.—The New Year opens with a prospect of harder times than we have experienced so far during the war. The Allies have formulated their terms on which a peace could be negotiated, and the military dictators of Germany jeer at them, so the war must be fought to a finish. In mining circles the item of chief interest has been the boom in tin. The maximum price for cash tin was £308 on December 19. Then the Government announced that tin is a war metal and foreshadowed some sort of restriction with regard to export. The price rapidly dropped to £269 on January 2. Since then the market has stiffened once more, and as we go to press the quotation is £298. Tungsten and molybdenum have been placed under Government control.

Transvaal.—The output of gold on the Rand during December was 697,137 oz., and in the outside districts 25,282 oz., making a total of 722,419 oz., worth £3,068,639, as compared with 698,271 oz., 24,568 oz., 722,839 oz., and £3,070,426 for November. The total yields for 1917 were 8,714,866 oz., 307,527 oz., 9,022,493 oz., and £38,323,921. The last figure compares with £39,484,934 during 1916. The number of native labourers on December 31 was 172,740, as compared with 169,083 at the end of November, and 191,547 at the end of December, 1916.

The gold mining companies operating on the Rand have declared their final distribution of dividends for 1917, with the exception of Consolidated Main Reef. The total dividends for the year amount to £6,581,436, as compared with £7,093,352 in 1916, £7,620,064 in 1915, and £8,070,659 in 1914. Of the 38 companies that pay dividends, 9 are in the Far East Rand. and they account for £2,879,671 or 43½% of the total, as compared with £2,466,414 or 35% in 1916. Of individual producers throughout the Rand, the payer of the biggest dividend is Modderfontein B which distributes £595,000. The next largest distribution comes from the City Deep, with £562,500. The Van Ryn Deep pays £508,675, the New Modderfontein £490,000, and the Modder Deep £425,000. Of the big consolidations, only Crown Mines has paid a dividend, and that, at £376,045, shows a continuance of the steady decline of recent years. East Rand Proprietary Mines has dropped out of the list of dividend-payers, we fear, for ever. Randfontein Central has not paid a dividend, as all the available funds are required for reorganization of underground policy; but in view of the litigation started by the company against Sir J. B. Robinson, the vendor of the control, the prospects under the new regime are not held to be as promising as at the time of the deal. The only new dividend payer is Government Areas. In the current year Springs should join the list. The rates of dividend throughout the older part of the Rand generally show substantial falls, and with the exception of Meyer & Charlton no mine perpetuates the glamour of the old days. Increased costs, diminishing ore reserves, and lower grade of ore mined cast a shadow on all parts of the Rand except the Far East basin.

For a year or two the prospects at the Princess Gold Estate have caused anxious consideration. The property is in the Goerz control, and is situated at Roodepoort, being the property adjoining the Witpoortje break. It is now announced that development at depth will be continued. The Central Deep shaft is to be put in better order, and to be sunk to the 15th level, at a cost of about £40,000. Recent developments have shown a larger proportion of the Main Reef to be payable, and good results have also been obtained on the South Reef. The new work will interfere to some extent with stoping during the next six months, and the monthly output will be restricted to 20,000 tons for that time. In order to provide the funds, the capital is first to be written down from £575,033 to £57,503, by reducing the nominal value of the shares from £1 to 2s., and then 500,000 new shares of 2s. each are to be issued, guaranteed by A. Goerz & Co., who will advance the money on loan until the scheme has received formal consent. The working cost will be substantially reduced when the new work is completed.

Two obituary notices have been posted this month in connection with mines on the Rand. The New Rietfontein company is to be liquidated; the Nigel Gold Mining announces that the mine was closed-down on December 31.

Cable advices announce that gold-bearing banket outcrops are being tested on farm Wilgepoort No. 244, some distance to the south-east of Heidelberg. It is reported that certain authorities correlate the reefs with the Van Ryn and Nigel reefs. Further information is awaited; in fact some reliable statement is required as to various prospecting operations in Heidelberg district generally.

Diamonds.—The cutting of South African diamonds is to be established in England. A training class has been inaugurated at the Municipal Technical Schools, Brighton, where fifty disabled soldiers are being taught the art. This new venture has been started by Mr. Bernard Oppenheimer, chairman of the South African Diamond Corporation, the company which controls the Pneils, Roberts Victor, and New Vaal River diamond-mining companies.

Rhodesia.—The output of gold during November is reported at £275,829, as compared with £289,978 in October and £317,135 in November, 1916. The figure is the lowest since March, 1914. The gradual decrease characteristic of the past six months has been largely due to suspension of operations at small properties. Other outputs reported during November were: silver 17,530 oz., copper 337 tons, wolfram 1 ton, coal 49,632 tons, asbestos 729 tons, diamonds 55 carats.

The dividends paid by Rhodesian mining companies during 1917 are reported by the British South Africa Company as follows:

	£
Eldorado Banket	45.000
Gaika	27,350
Giant	9.828
Globe and Phœnix	273,333
Golden Valley	1,197
Kimberley (Mashonaland)	12,000
King Asbestos	6.245
Lonely Reef	54.201
Rhodesia Chrome	21,000
Selukwe Colu bia	9,350
Selukwe	3,732
Shamva	157,500
Wanderer (Selukwe)	30,000
Wankie Colliery	40,524
Total	£691,260

This compares with £641,981 declared during 1916, and is the greatest amount declared by Rhodesian mining companies in any one year. The total cash dividends declared by Rhodesian mining companies to December 31, 1917, amounts to £5,287,347.

The directors of the Bwana M'Kubwa company have abandoned the idea of establishing a leaching and electro-deposition plant for the treatment of the oxidized ores found at this mine, owing to the impossibility of obtaining the necessary plant. During the past few months attention has been turned to the new development introduced by Minerals Separation, whereby oxidized ores can be concentrated by flotation, and an agreement is in course of settlement for the erection of a 100 ton unit to treat the ore on this system.

West Africa.—The yield of gold during November is officially reported at £126,915, as compared with £126,295 in October, and £130,101 in November, 1916.

Nigeria.—Last month we commended the Jantar company for issuing its reports so promptly, and we expressed a wish that other Nigerian companies should follow the example. There are occasionally, however, good reasons for delays in these matters. For instance, the Forum River had a very sound reason for not issuing its report for the year ended March 31 last, until December, for the accounts and engineer's statements had been the victim of three successive torpedoings on their way from Nigeria. We note with pleasure that the shareholders in general meeting voted 200 guineas to war charities, more particularly those connected with the mercantile marine.

The Northern Nigeria (Bauchi) company provides one of the brightest spots in the Nigerian tin-mining industry. During the past year the drilling campaign has substantially added to the reserves, which are now estimated to contain 6,876 tons of tin concentrate, as compared with 3,340 tons a year ago. The acquisition of water rights at the Kwall falls is of great importance, as it will be possible thereby to produce power at a much lower cost than by any other method. A competent hydraulic engineer is now on the spot preparing plans for a hydro-electric station. The excellent position in which the Bauchi company finds itself is due to Major A. R. Canning, who recently resigned the management to join the Forces, and the action of the shareholders in voting him an extra honorarium was fully justified.

Australasia.—Advice is to hand that the plan for controlling the sales of Australian copper has been settled, and that the Copper Producers' Association Proprietary, Limited, has been formed. The leaders of this new movement are the boards of the Mount Morgan, Mount Elliott, Mount Lyell, Hampden Cloncurry, Wallaroo & Moonta, and the Electrolytic Smelting & Refining Co. Details of the policy are not yet to hand. The three metals, lead, zinc, and copper, are now fully controlled in Australia.

The Mount Morgan results for the half-year ended November 25 last have been received by cable. The ore mined was 186,085 tons from Mount Morgan and 20,286 tons from Many Peaks. The concentration plant treated 91,135 tons for the production of 31,693 tons of concentrate. The smelter treated 93,518 tons of Mount Morgan ore, 9,138 tons of coarse concentrate, 19,242 tons of sintered table and flotation concentrate, 26,844 tons of Many Peaks pyritic ore, and 1,432 tons of other ores. The blister copper produced contained 4,114 tons of copper and 48,081 oz. of gold. The revenue from all sources was £625,161, and the working cost £500,317. A dividend of 10% for the half-year, absorbing £100,000, has been declared.

The Hampden Cloncurry Copper Mines smelted 54,898 tons of ore for a yield of blister copper containing 3,357 tons of copper, 1,264 oz. gold, and 22,412 oz. silver during the half-year ended August 31 last. The net profit was £96,858. Owing to lack of shipping, 2,800 tons of blister is awaiting transport to Port Kembla for refining, and until this copper is realized the funds of the company are not available for distribution as divided.

In our November issue we recorded that it had been necessary to suspend operations at the remodelled smelter at Mount Elliott on account of the impossibility of obtaining a sufficiency of honest and capable workmen, and that Mr. W. H. Corbould was proceeding to erect additional labour-saving devices. The yearly report of the company issued just before Christmas mentioned that in the meantime, until the production of copper is resumed, the financial resources would be over-taxed. At the subsequent meeting of shareholders the Chairman was able to announce that a loan had been advanced by the Ministry of Munitions, so that this source of anxiety is removed. The ore reserves have been re-estimated. At Mount Oxide the round figure is 250,000 tons averaging 10% copper; at Consols 400,000 tons averaging 4%; in the Dobbin 80,000 tons averaging 5%; in the Lady leases 30,000 tons averaging 5%; in the Great Australia the limestone lode contains 100,000 tons averaging 2½% and the jasper lode 80,000 tons averaging 5%; at the Elliott there is 10,000 tons averaging 10%, and 600,000 tons averaging 3%. The Argylla property promises great things, but no exact figures can be given. In the future it will be possible to treat the lower grade ores here mentioned, but additional plant will be required. Eventually, also, an entirely new smelting plant will be desirable, built in a more central and convenient position. The railway connections also will have to be greatly improved.

The Flinders Copper Co. owns property in the north of the Flinders Range in South Australia, near Yudnamutana, about 80 miles from Farina railway station. The original local owners had intended to smelt the oxidized ores, but when the property was taken over by the present English company the late Mr. D. D. Rosewarne recommended leaching. The South Australian Government Geologist confirms this view. Mr. C. S. Wesley, the manager, estimates the reserve at 100,000 tons, which should give 450 tons of electrolytic copper per year with a 50 ton plant. In the meantime the company is shipping hand-picked ore to the smelters.

In our September issue our West Australian correspondent referred to the Tuckabianna district where gold-mining operations are attracting attention. Another correspondent writes amplifying this information. Tuckabianna is in Murchison goldfield, and is 17 miles east from Cue on the Cue-Sandstone-Lawlers track. The 1915 boom was due to the discovery of a few rich splashes in quartz, but the present activity owes its origin to the discovery of a rich ironstone lode in the Toscano claim. The characteristic of the deposit is a jasper bar, on each side of which run ironstone formations. The Toscano lode is about 40 ft. wide, but it is only auriferous on the 8 ft. adjoining the foot-wall. During the last year 400 tons was extracted, yielding £8,000.

India. — Developments at Ooregum have not been good for some time, but a recent report contains rather more hopeful reading. On the 57th level in Oakley's section assays have given 24 dwt. over 3½ ft., and the face is still promising after driving 62 ft.

The Champion Reef has maintained its rate of dividend in spite of less ore having been treated. The factors contributing to this result are the higher grade of the ore, a reduction of costs, and an improved recovery in the cyanide plant. Mr. H. J. Gifford, the superintendent, expressed a fear that during the current year the amount of ore mined will show another decrease. At the meeting of shareholders, however, Mr. Edgar Taylor spoke more cheerfully, as he was able to report that in the section between the Carmichael and Glen shafts ore of higher grade had recently been found, which may possibly prove to be the beginning of another ore-shoot.

The output of gold in India during 1917 was worth £2,214,163, as compared with £2,305,652 in 1916, and £2,369,382 in 1915.

Canada.—As foreshadowed last month, the Dome Mines company at Porcupine has decided to suspend mining operations owing to high costs and scarcity of suitable labour and to confine the work to sinking and development. This mine has been worked during the last two or three years on a low-grade basis, the reserves of this class of gold ore being very great. Under these conditions, a rise in cost makes serious inroads into profits.

The new discovery of gold at Rickard township near lake Abitibi is attracting attention. Among the people taking an interest are the directors of the Cobalt company, the Mining Corporation of Canada. Two diamond drills have been despatched by this company.

A curious situation with regard to the ownership of discarded tailing has arisen at Cobalt. The Nova Scotia Mining Co. had dumped its old tailing into Peterson lake in early days. The bed of this lake belongs to the Peterson Lake Mining Company, which now claims ownership of the dumped tailing. The successor to the Nova Scotia Co., the Dominion Reduction Co., desired to recover the tailing for re-treatment, but the Peterson Lake Co. succeeded in getting a judgment declaring that the Dominion Co. has no claim to any tailing dumped before July, 1915.

United States.—The Anaconda Copper Mining Company is about to commence the manufacture of copper rods and copper wire suitable for use by electricians. As we mentioned some time ago, the tendency is to electrify all the railways in Montana and the adjoining states, so that the company will have a big local market. Since the company started zinc production, the eventual establishment of a brass foundry has also been seriously contemplated. While writing of the Anaconda we may mention that the company continues to purchase shares in other producing mines, notably the Inspiration, in Arizona.

The Arizona Copper Company reports that the fire at the Coronado mine, which broke out just as the labour troubles were settled, has been overcome by flooding. The water is now being removed by pumping, and work will recommence shortly.

The output of steel in the United States during 1917 is estimated at 42,600,000 tons, an increase of 2,000,000 tons as compared with 1916. The American authorities estimate the British production at 10,500,000 tons, that of Germany and Austria-Hungary 24,000,000 tons, and the total of the world 83,900,000 tons.

Mexico.—Advices received by the London silver market point to a slow and gradual increase in the output of silver in Mexico. Probably this changed condition has been a cause of the hitch in the proposed fixing of silver prices by agreement between the United States and British governments. Another sign of improvement in Mexico is provided by the action of the Avino Mines of Mexico, Limited, which company has appointed Mr. William Roberts general manager and sent him out with the object of re-starting operations.

Brazil.—The directors of the St. John del Rey company announce the cutting of the lode on the 21st horizon at a vertical depth below outcrop of 6,066 ft., and that the nature of the ore disclosed is satisfactory. The company has recently been selling its gold in New York; now comes the news that the Brazilian authorities are buying it.

Russia.—The speeches of Mr. Leslie Urquhart at the meetings of the Kyshtim, Irtysh, and Tanalyk companies, together with his articles in the *Nineteenth Century* and the *Glasgow Herald*, have done much to counteract the gloomy views generally taken with regard to the future of Russia and Siberia. Few people know Russia as intimately as Mr. Urquhart. He, and other authorities equally well versed, believe that Bolshevik influence will not spread to the south or east of a line running from Kieff to Perm. A government independent of the Bolsheviks has been organized at Tomsk for Siberia. At the time of writing even the Bolsheviks are dissatisfied with German demands, a good augury for the future of Russia. The mines and works of the companies named above are still in operation, though on a reduced scale. The Kyshtim is one of the two companies that continue to produce copper.

It will be remembered that the Russian Mining Corporation acquired the Altai Concessions containing the Zmeinogorsk lead-zinc-silver mine just before the war. Under the circumstances it was difficult to raise capital to develop the property adequately. An arrangement was, however, made with an English financial house operating in Russia for the supply of capital in exchange for a 28% interest, and thereby a campaign of drilling and investigation was made possible. The directors now announce that Russian capitalists have come forward to buy the whole of the corporation's interests. A new company is to be formed in Russia called the Altai Mines, Limited, with a nominal capital of 10 million roubles and a working capital of 2½ million roubles. The corporation's consideration is 36,400 shares of 100 roubles each. Of these shares, 16,000 have been sold for 1,520,000 roubles. During the investigations referred to drilling was done on an old copper mine known as the Byeloussovsk, and the existence of from 1½ to 2 million tons of ore has been indicated. The average assay of the drill cores is 3½% copper and 9% zinc.

THE BROKEN HILL SOUTH MINE

By W. E. WAINWRIGHT and P. H. WARREN.

The Broken Hill South mine is at present one of the most important mines on the Barrier Range, by virtue of the extent of its reserves of high-grade lead-zinc-silver ore, and the prospects for further discoveries in depth. The authors of this article are the general manager and the assistant underground manager respectively.

THE MINE.—The Broken Hill South mine is at Broken Hill, New South Wales, 340 miles from Port Adelaide, and 225 miles from Port Pirie. A 3 ft. 6 in. gauge railway connects to Port Pirie, but there is a break of gauge to 5 ft. 3 in. at Terowie, 195 miles from Broken Hill on the journey to Port Adelaide. A 4 ft. 8½ in. gauge railway line is at present under construction to Condobolin, which will join Broken Hill to Sydney, a distance of 826 miles. The leases owned by the Broken Hill South Silver Mining Company are two in number, and the area is slightly under 70 acres.

The great Broken Hill lode, which has been worked since 1884, is situated in the low-lying Barrier Ranges, about 1,000 ft. above sea level. The surrounding country is extremely arid and dry, the rainfall averaging only 8 inches per year. The climate, though hot and dusty in summer, is healthy, while the weather during the winter months is mild and enjoyable. The Broken Hill mines, of which the South is one of the most important, constitute the only industry of the district (if sheep-raising be excepted) and directly support a population of 30,000 in the city of Broken Hill. The lode has an average course of North 20° East, and dips steeply to the north-west. Various companies have conducted mining operations on a length of 3 miles. The lode varies in width from a few inches to 400 ft. The deepest workings are 1,815 ft. below the surface, with ore

GENERAL VIEW OF THE BROKEN HILL

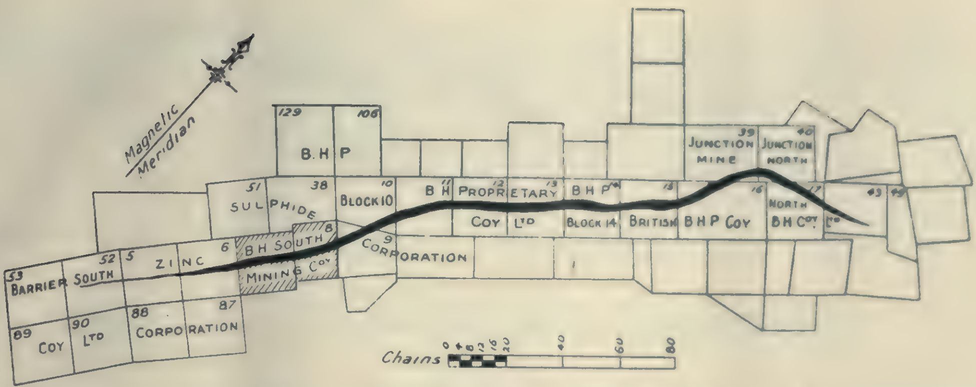


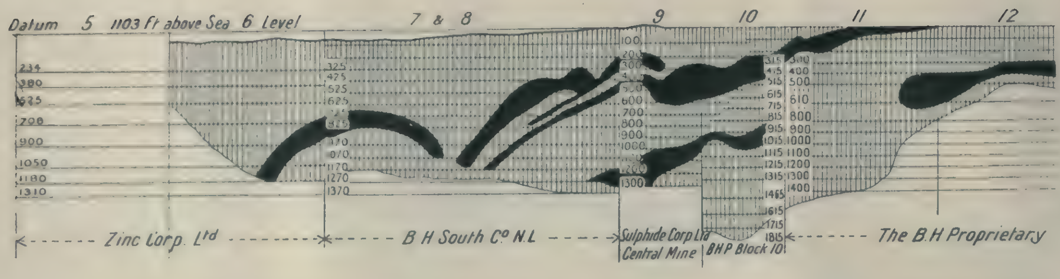
FIG. 1. PLAN OF BROKEN HILL, SHOWING THE RUN OF COUNTRY IN WHICH ORE-BODIES OCCUR.

still showing underfoot.

The value of the output from the inception of operations to the end of 1915 was £90,156,000, and the dividends and bonuses paid for the same period were over £20,000,000. The total ore hauled from 1903 to 1916 was 19,243,155 tons. The estimated ore reserves of the various mines approximate 12,000,000 tons.

Owing to Broken Hill's isolation, materials are expensive. Coal costs on an average 35s. 3d. per ton delivered, Oregon pine 19s. per 100 super feet, and Australian hardwood 48s. 2d. per ton. Present prices are much higher, namely: coal 45s. 7d. per ton; Oregon pine

SOUTH MINE, LOOKING SOUTH.



Footwall or Eastern Vein (in places too poor and narrow to be worked) shown thus

FIG. 2. LONGITUDINAL SECTION OF BROKEN

27s. 4d. per 100 super feet; hardwood 50s. 8d. per ton. The timbers mentioned are extensively used for constructional work and underground timbering. Water is very expensive, costing 5s. per 1,000 gallons. The Australian Unions provide the labour; the supply does not meet the demand, and high rates of pay are in force. The minimum rate at present is 12s. 3d. per day, and miners on contract average about 18s. per day.

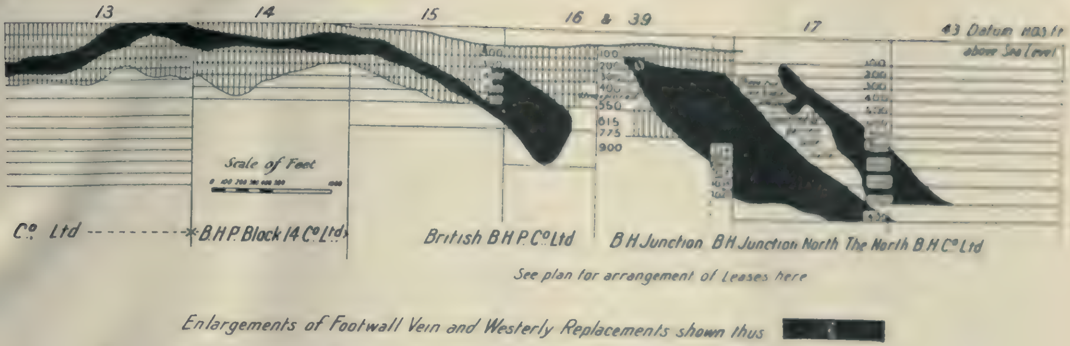
The Broken Hill South Silver Mining Company, No Liability, operates leases 7 and 8, shown on the accompanying plan (Fig. 1). The authorized capital of the company is £200,000, of which £163,727 has been subscribed. The ore raised to the end of 1916 totals 4,374,027 tons, the average assays being 16·3% Pb., 6·7 oz. Ag., and 13·7% Zn. The value of the output was £7,519,703. The amount distributed in dividends to December, 1916, is £1,995,000, or £9. 19s. 6d. per share. The ore reserves at present are estimated at 3,350,000 tons.

The South is the biggest ore producer on the field; 320,699 tons of ore was hauled for the year 1913, producing 52,011 tons of concentrates assaying 69·1% Pb., 23·6 oz. Ag., and 6·6% Zn. 3,077,250 super feet of timber (nearly all Oregon pine), 200,000 lb. of explosives, and 15,365 tons of coal were used during the year 1913. Normally the mine employs about 1,400 men, 1,000 underground and 400 on the surface.

GEOLOGY.—For many years the geology of the Broken Hill district, and the genesis of the ore, was not clearly understood, the ore-bodies being vaguely referred to as "saddles." Several recent independent investigations have, however, done much to clarify the whole matter. The subject will be found discussed in great detail in the Report of the Geological Sub-Committee of the late Scientific Society of Broken Hill (Transactions of the Australasian Institute of Mining Engineers, vol. xv.); also in a valuable monograph work prepared by Sir Douglas Mawson, of the Adelaide University. The lode strikes approximately North 20° East. When viewed from the west or east a narrow lode some 6ft. to 10ft. wide is seen occupying the eastern side of the deposit. This lode is variously called the "foot-wall lode," "eastern vein," and "fissure lode." It is more or less continuous throughout the field, and is closely associated with a "bedded fault" on its foot-wall or eastern side. The lode dips steeply to the north-west and occasionally enlarges sufficiently to enable fairly extensive mining operations to be carried out upon it. Springing from this lode, on the western side, are a number of saddle-shaped bulges. These are the huge ore-bodies which have yielded such large amounts of ore.

Reference to the plan and section (Figs. 1 and 2) will show that the Broken Hill Proprietary mine occupies an approximately central position. The ore-bodies in this mine may be regarded as forming the apex of a longitudinal arch, from which they pitch respectively north and south (see Fig. 2) at fairly flat angles. The South mine is about three-quarters of a mile south of the Proprietary. Though the outcrop of the narrow lode can be traced right through the mine, no large bulges were encountered until a depth of 425ft. was reached, at which level the first of a series of saddle-shaped ore-bodies was met with, pitching into the mine from the Sulphide Corporation, immediately to the north. The workings have now reached a depth of 1,270ft., where the ore-body in question has pitched to a point about 800ft. south of the northern boundary. The length of ore-bearing ground in the mine, from the Sulphide Corporation boundary to the Zinc Corporation boundary, is about 2,500 ft.

Figure 3 shows a vertical cross-section through the mine. The ore-bodies do not all pitch at the same angle. Occasionally, there-



HILL LODE, LOOKING NORTH-WEST.

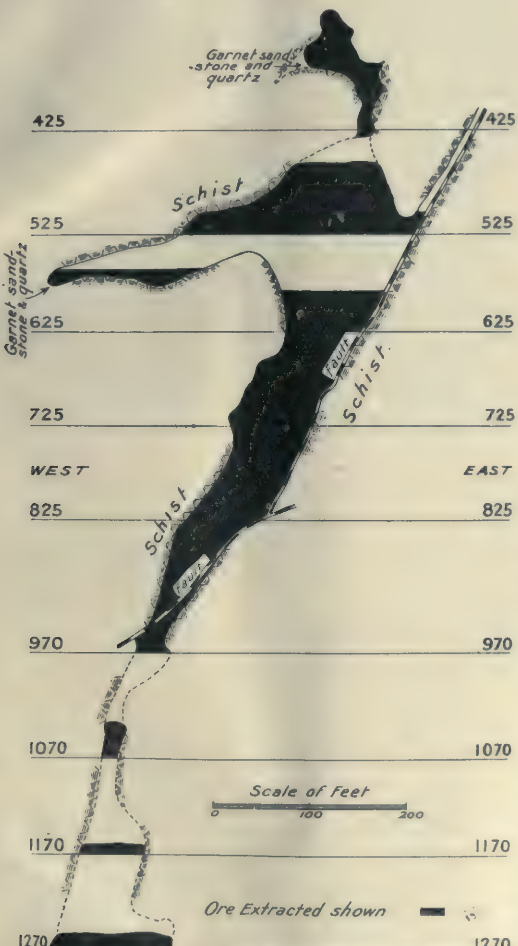


FIG. 3. CROSS-SECTION THROUGH ORE-BODIES.

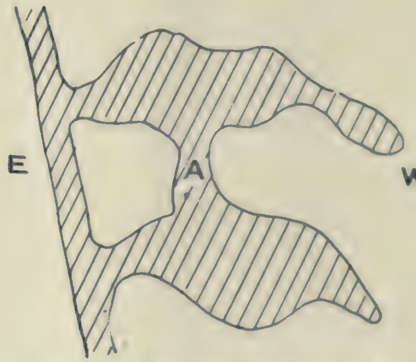


FIG. 4. TWO ORE-BODIES CONNECTED BY ARCH.

fore, one will fuse with another. Furthermore, two separate ore-bodies may sometimes connect through the intervening arch of schist or quartzite, as at *A* in the sketch in Fig. 4. The western side ore-bodies do not necessarily come to the surface; the top of such an ore-body has lately been discovered at the 725 ft. level in the southern end of the property. Diamond drilling on the 825 ft. and 970 ft. levels showed this ore-body to be pitching at a flat angle south, toward the Zinc Corporation boundary. As there is a considerable extent of unexplored country in the Mineral Lease 7, above the 1,270 ft. level, there is every chance of further such similar occurrences of ore being discovered.

NATURE OF THE ORE.—In the early days of Broken Hill, the oxidized ores, resulting from secondary enrichment, were mined in great abundance from the upper levels of those mines in the central portion of the district, namely, the Proprietary, Block 10, and Block 14. The ore-bodies of the South mine were, however, too deep-seated to have come under the enriching influences of percolating waters, except in a minor degree; so the valuable ore existed in the condition of primary sulphides with occasional patches of secondary sulphides, little carbonate of lead being found.

Broadly speaking there are two specific classes of sulphide ore in the mine, namely: (1) silicate gangue ore, and (2) calcite gangue ore. The following are typical analyses:

	(1) Silicate Gangue Ore %	(2) Calcite Gangue Ore %
SiO_2	33·4	31·0
Pb	18·2	19·5
Zn	19·6	11·0
Fe	4·2	3·5
S	15·3	10·0
Mn O	3·0	2·7
Ca O	4·7	12·4
Al_2O_3	1·7	2·6
Mg O	Trace	Trace
Co_2	0·6	0·6
Ag (oz. per ton)	13·2	3·8

These analyses, which do not necessarily show the average value of the ore mined, indicate the greater richness of the silicate gangue ore in zinc and silver, as compared with the calcite gangue ore. The sulphides are a close mixture of galena and zinc blende, carrying silver; the gangue minerals are calcite, quartz, and felspar, and sometimes fluorspar. The silicate gangue ore-bodies carry rhodonite, garnet, and quartz. Pyrite is also met with. The ore is even in quality, and homogeneous in character. Occasionally unmineralized inclusions of country rock are found in an ore-body. The presence of rhodonite in the silicate gangue ore makes it harder and more difficult to deal with in every way. The majority of the ore-bodies in the South mine, however, are of the calcite gangue class.

GENESIS OF THE ORE.—Mr. J. B. Jaquet, in his "Memoirs of the Geological Survey of N.S.W., 1894," claims that the crystalline schists and gneisses of the country rock are heavily metamorphosed sediments. Later work has confirmed this view. Briefly the conditions leading to the deposition of the ore may be summarized as follows: (1) The existence of sedimentaries of Pre-Cambrian age; (2) Intense regional metamorphism due to the intrusion of acid igneous rocks causing the formation of schists and gneisses, which were so violently contorted and folded as to provide both suitable cavities for the reception of the ore, and the lines of weakness along which the mineralizers were enabled to travel; (3) The foot-wall lode is regarded as the chief channel through which the mineralizers rose, flowing into the cavities formed in the soft mica schist of the western side, and, where conditions were favourable, eating into and replacing the country rock by the process known as metasomatism.

MINING METHODS. — The mine is equipped with six shafts, of which Nos. 1 and 4 are hoisting shafts. No. 1 is the main hoisting shaft, and measures 12 ft. 10 in. by 9 ft. 6 in. in the clear. It has three compartments, two of which are used for hoisting and the third for ladder-way, water and air pipes, and electric

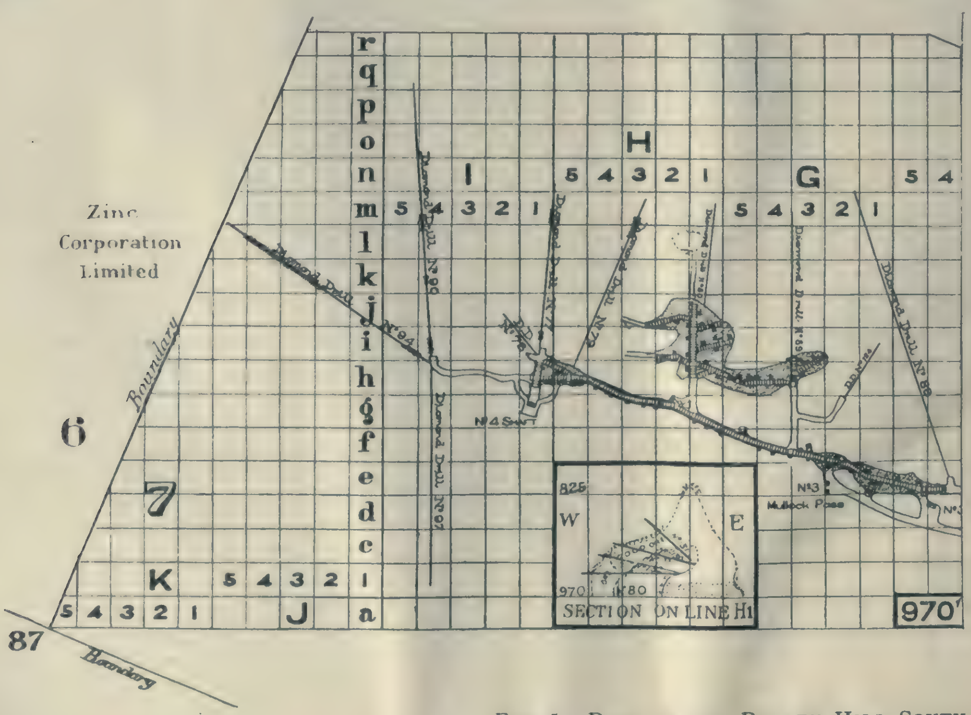


FIG. 5. PLAN OF THE BROKEN HILL SOUTH

light and telephone cables. The shaft is vertical, in firm foot-wall country. The timbering is of the frame-set type; the sets are 5 ft. apart and supported on bearers 50 ft. apart. The dimensions are given in Fig. 6. A feature of this shaft is the automatic device for indicating the position of the chairs in the shaft; a description of which may be found in a paper by W. E. Wainwright, in the Transactions of the Australasian Institute of Mining Engineers, vol. xiii., page 61. The shaft has sufficient width to allow of two trucks being caged together end on. The winding engine is of the direct-acting high-pressure horizontal type. It was designed on the mine, and is capable of handling 8,000 tons of ore per week, working two shifts per day.

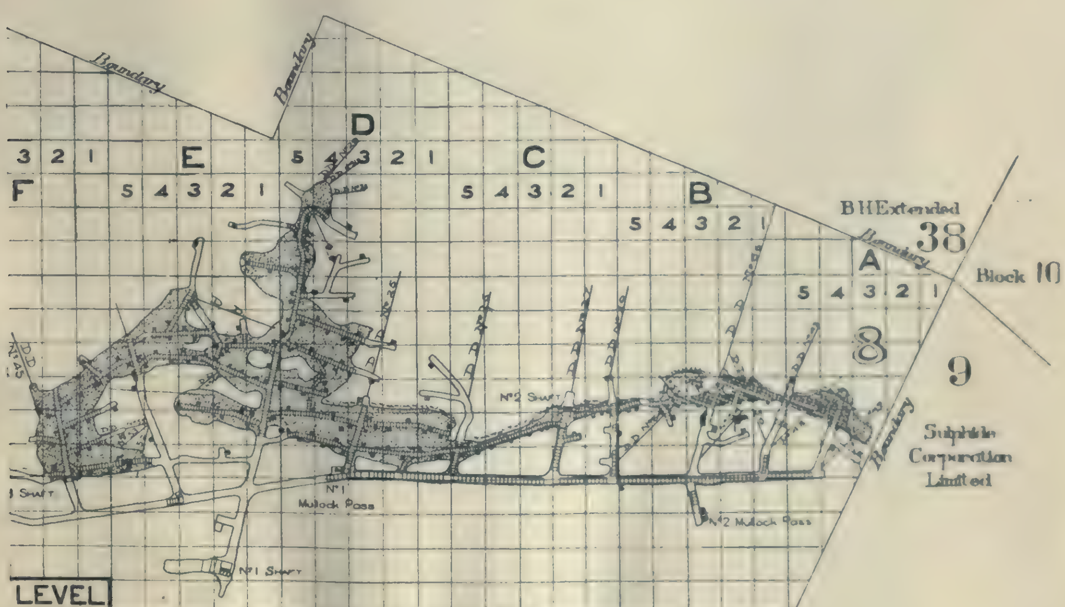
No. 2 shaft was originally the main hoisting shaft, but owing to the fact that it is situated west of the foot-wall, and passes through two large ore-bodies, it became unsuitable for hoisting ore, and is not now in use down to the 970 ft. level except as an escape for upcast air. Below the 970 ft. level this shaft is in firm ground, and is used as the first point of attack in development and preparatory work in opening up a new level. An air-driven winch is placed at the 970 ft. level, the mullock (the Australian term for waste) from development openings being hoisted through the shaft and distributed in the various stopes. This shaft is also of three compartments, its dimensions being 11 ft. by 4 ft. 8 in. in clear.

No. 3 shaft is a three-compartment shaft, the same size as No. 2, and is used for conveying timber, and for the distribution of development mullock underground, and is also very convenient for travelling from level to level without disturbing hauling operations.

Nos. 4 and 5 shafts are situated at the southern end of the property. They are both three-compartment shafts, 11 ft. by 4 ft. 9 in. within clear. These shafts are both comparatively new. It is intended to use them in the exploitation of the new ore-bodies recently opened up in that portion of the mine. They are equipped with 300 h.p. electric winders, speed 1,000 ft. per minute.

No. 6 shaft, at the north end of the property, close to the boundary, is at present being sunk, a depth of 625 ft. being reached. This shaft will be used chiefly for ventilation to take the upcast air from the mine. Provision is made for the erection of a large exhaust fan at the mouth of the shaft. The internal dimensions of the shaft are 12 ft. 10½ in. by 9 ft. 6 in.

All the shafts (with the exception of the upper portion of No. 2) are in firm foot-wall country. Main drives, 9 ft. by 8 ft., are driven



Mine Workings on the 970 ft. Level.

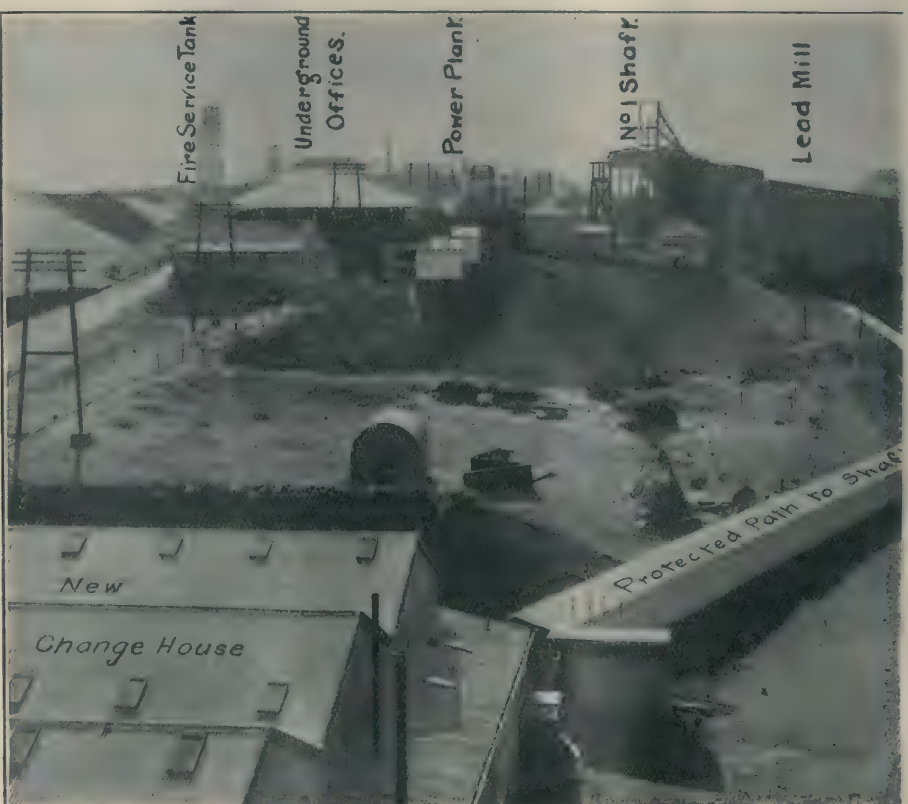
in foot-wall country, parallel to the course of the lode, which is reached by means of suitably spaced cross-cuts. Development work on a new level is closely followed by diamond drilling, by means of which the locality, size, and quality of the ore-bodies may be approximately determined.

The problem of mining the ore is beset with many difficulties, the chief of which are: (1) flat pitching ore-bodies irregular in shape; (2) the ore in some portions of the mine is heavy, and does not hang together well; (3) the hanging wall is frequently a treacherous soft schist, lying very flat; (4) several large faults traverse the ore-bodies; (5) in the early days of the mine an attempt was made to work the stopes without filling, which caused local subsidences; (6) creep movements from neighbouring mines. The working policy now in operation, and which has proved effective, is the result of several years' development. Briefly the scheme is to mine the ore on the open stope system with flat backs to within 30 ft. of the level above, the ore remaining being subsequently extracted by underhand stoping, using square sets.

Detailed description of these methods may be found in the following papers by A. Fairweather: Open Stoping on Wide Lodes (Transactions Australasian Institute of Mining Engineers, No. 10, page 136), and Picking-up Bottoms after Open Stoping (Transactions Australian Institute of Mining Engineers, No. 13, page 1).

Mill residues are used for filling depleted workings, this work being carried on concurrently with the mining of the ore.

Three mullock passes are provided in firm foot-wall country. The sinking of a fourth is in contemplation for the systematic exploitation of the southern end. Owing to the irregularity of the ore-bodies, it is not possible to make use of mechanical transmission, except in five cases where 24 in. belt-conveyors are used to join up main sections of the passes through cross-cuts in foot-wall country. The distribution of the mullock to the stopes is done by trucking.



GENERAL VIEW OF BROKEN HILL

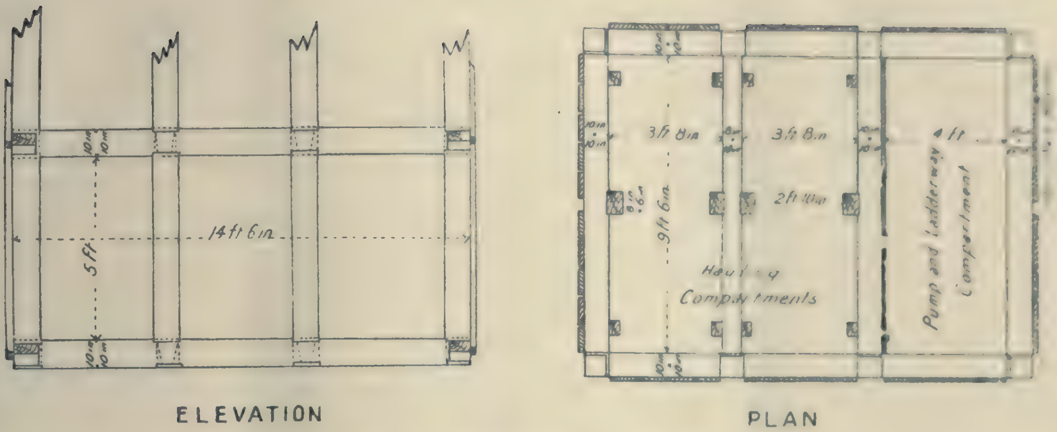


FIG. 6, TIMBERS OF NO. 1 SHAFT.

The ore is mined on contract, the miners being given a price per ton to break and deliver the ore to the shaft. The truckers and fillers are in the same contract as the miners, receiving seven-eighths of the miners' earnings. The trucks of ore are conveyed direct to the mill bridge at the surface, and they are there weighed by the mining company's weighman, an operation which is checked by the miners' representative.

SOUTH MINE, LOOKING NORTH-EAST.

THE EVOLUTION OF ORE DEPOSITS
FROM
IGNEOUS MAGMAS

By W. H. GOODCHILD, A.R.S.M., M.Inst.M.M., F.G.S.

The Author discusses the principles governing the segregation of ore deposits from rock magmas, introducing several new factors in addition to those already put forward by geologists. He shows how the specific action of certain gases and mineralizers, notably hydrogen and its compounds, together with changes in volume accompanying the later chemical adjustments, explain many obscure problems in the formation of ore deposits.

Natural Metallurgy.

THE author suggested in a former article on the constitution of ore minerals (see the Magazine for May) that a more thoroughgoing application of the principles of physics and chemistry than has hitherto been attempted in the study of ore deposits bids fair to throw much new light on the processes operative in the formation of such deposits and on the relative distribution of their richer and poorer parts. The present article, to which the former was of an introductory character, can perhaps best be summarized as a study in "natural metallurgy" for, as will appear in the sequel, the processes operative in the formation of ore deposits from igneous magmas bear a much closer resemblance to the ordinary familiar processes of metallurgy, such as matte smelting, bessemerization, flotation, etc., than might be supposed from a perusal of the present day literature of ore deposits. In fact they are in principle these very processes, but refined, intermingled, and elaborated by means of the various artifices of physical chemistry.

Method of Treatment.

The treatment of the subject is necessarily on lines that are to some extent novel and unfamiliar to most mining engineers, though less so to metallurgists who may have taken the trouble to keep pace with the more modern developments of their art and the scientific conceptions of facts underlying it. The author has therefore adopted, for the sake of clearness of exposition, the device of discussing in some considerable detail an example of nature's metallurgy that has been studied with unusual thoroughness and is very widely known. The example is also specially selected because it conveniently illustrates many processes and principles in simpler form than is the case of, perhaps, the majority of ore deposits derived from igneous magmas, especially where these are derived by differentiating complex mixtures containing a greater number of components and in which gases play a relatively more important part. Starting from the simpler case it then becomes possible to outline or suggest how some of the more complex types may be developed, thus briefly illustrating several of the more important methods and principles whereby the so-called vagaries of ore deposition may be reduced to expressions of definite and ascertainable laws such as can be usefully applied to the discovery, exploitation, and development of mineral deposits. It is hoped in this way to bring to a focus the vast potentialities and importance to the metal-producing industry of this branch of applied physical chemistry, which is one that richly deserves closer study.

The Sudbury Controversy.

The case of the huge nickel and copper deposits of the Sudbury region affords a striking example, on the one hand, of the discord that arises when attempts are made to interpret the problems of ore occurrence and deposition without due regard to many of the principles of physics and chemistry, principles which are on the whole so soundly established that their application to the processes of ore formation cannot be reasonably doubted, and, on the other hand, of the harmony and enlightenment that may ensue when an ampler use is made of physico-chemical knowledge. Controversy in regard to the origin of the Sudbury ore deposits has now continued for upwards of a quarter of a century. The great gold deposits of the Rand may be cited as a parallel case. In neither instance has full advantage been taken of the facts and principles of physics and chemistry in the multitude of attempts that have been made to attain clear and coherent conceptions as to how the ore deposits were formed, the causes of variation in their modes of occurrence, and the seemingly erratic distribution of the valuable constituents within the deposits. What applies to these two much studied occurrences applies with even greater force to the multitude of ore deposits the world over that in most cases have not received so much painstaking attention by a host of geological observers.

The position in regard to Sudbury may be briefly summarized as follows. There are now two fairly well-defined schools of thought. The first or "field" school maintains: (*1*) that a preliminary concentration of sulphides was effected in the neighbourhood of the lower margin or floor of the so-called nickel eruptive by the sinking of non-consolute drops of sulphides in the melt previous to the solidification of the silicates, the process being comparable in principle to the sinking of matte in smelting operations; and (*2*) the sulphides were subsequently rearranged in varying degrees by diverse processes giving rise to several different types of ore deposits all situated more or less in the near neighbourhood of the floor of the eruptive in contradistinction to the roof or other positions remote from the floor. The geologists of this school are, however, unable to give anything more than somewhat sketchy outlines of the processes which they believe to have been involved in these later rearrangements.

The second or "petrographic" school base their views very largely on microscopic studies of small samples of the ores and rocks. They agree among themselves on one point, namely, that the bold, clear, and reasonable conception of the field school of geologists is an untenable hypothesis in view of the structural relationships of the ore and gangue minerals as revealed by the microscope and the examination of thin and polished sections. They make the most of those details of the field evidence concerning which the field school offer no very comprehensive or convincing explanations. At the same time they show no consensus of opinion as to the precise interpretation to be put on those structures to which they have devoted their particular attention. Hydrothermal action, "introduction" of the ore minerals "at a late magmatic stage" by solutions or by the aid of "mineralizers," involving "replacement" to a greater or less extent of the silicate minerals, form the gist of their rather vague and ill-defined hypotheses as to the genesis of the ores.

The Development of Metallography.

In order to get a well balanced view of the relative positions of the two schools it may be as well to review briefly the history of metallography, the sister science to petrography, which is a branch of physical chemistry that has advanced by leaps and bounds during the past few years under the powerful stimulus of the industrial demands for metals and alloys. Now the earlier microscopical investigators examined and prepared photo-micrographs of rocks and ores before this method of research was so extensively developed for the examination of metals and alloys, and gave rise in the latter connection to the somewhat misleading term "metallography" for a science that now embraces many other important weapons of research than the mere use of the microscope and the preparation of photo-micrographs. Metallographers soon found that it was often quite impossible to interpret the microscopic structures exhibited by metals and alloys, even in comparatively simple systems, without recourse to collateral research on certain specified lines. These facts, necessarily unknown to the earlier geological workers of both schools, appear to have been largely overlooked by later users of the microscopic, or as they prefer to call it, metallographic method for the investigation of rocks and ores. Consequently the interpretation of the microscopic structures has not been guided by well defined physico-chemical principles hitherto, but has been mainly akin to guess-work, with the result that there is serious confusion not only in regard to minor points but to matters of fundamental and basic significance in connection with many of the larger problems connected with the genesis of the deposits and the relative distribution of the different metals contained therein. It may be remarked in passing that this is the position not only as regards the Sudbury deposits but the majority of ore deposits that have been the subject of microscopic investigation.

Comparative Review of some Magmatic Ore Deposits.

Before proceeding to a discussion of the petrographic evidence it will be as well to present briefly the main features of the field evidence in support of the view that the sulphides underwent a preliminary concentration in the neighbourhood of the lower margin of the eruptive by gravitative descent in the fluid silicate melt. This can best be presented by way of the comparative study of ore deposits, rather than by reference to the Sudbury deposits alone. Furthermore it will serve to illustrate the scientific value of the comparative study of ore deposits.

The platiniferous dunite of the Nischne-Tagilsk igneous complex in the Urals may be regarded as the prototype of the class of metalliferous deposits in which preliminary concentration is effected by gravitative descent. It is now generally recognized that this kind of magmatic differentiation is effected by the sinking of early formed olivines in the melt. The Nischne-Tagilsk complex also shows the striking centralization of the ultra-basic differentiate in the lower central regions of the basin-like igneous mass, while the most basic phase, dunite, is encircled by a ring of pyroxenite. It has been established that platinum occurs not infrequently as minute metallic grains enclosed completely in olivine, so that the separation of the metal prior to olivine is certain according to the recognized petrographic criteria, while the question of replacement in the sense used in the case of the sulphide deposits does not arise. Although platinum is present in such extremely minute quantities in the igneous complex taken as a whole its concentration in the ultra-basic differentiate can be readily understood as being due in part to encasement in sinking olivines and in part to entanglement among the crystals of the sinking swarm.

The platiniferous nickel-copper deposits of the Insizwa region, often dubbed the Sudbury of South Africa, may be cited next as an intermediate type showing some increase in complexity over the prototype. The Insizwa sheet, which originally covered an area probably considerably exceeding a thousand square miles, was essentially an olivine-gabbro melt, perhaps a little richer in magnesia than usual, which became highly differentiated in much the same manner as in the previous instance. Perhaps the most interesting chemical feature of the magma, as indicated by numerous rock analyses, was the unusually small amount of hydrogen, a point of special interest in connection with the genesis and characters of the ore deposits. The most basic differentiate is picrite, consisting roughly of about 60% olivine, 30% pyroxene, and 10% felspar, and the same kind of centralization of the picrite is shown as in the previous case; but whereas in the Nischne-Tagilisk complex the most basic differentiates are the anchi-monomineralic (olivine) rock, dunite, with a surround of pyroxenite, the Insizwa basic phase is a mixture of the two minerals with olivine predominating.

The sulphides occur as a dissemination near the basal margin of the eruptive and show a strong preferential association with the areas overlain by picrite, that is to say, with the picrite differentiate. The platinum is not present as sperrylite, and is distributed partly in the silicates and partly in the sulphides, while the ratio of precious to base metals is higher than appears to be usual in nickel-copper deposits. The proportion of sulphur to the useful metals is exceptionally low; in short, the magma was not only comparatively deficient in hydrogen but also in the other volatile substance, sulphur. The characteristics of the sulphides themselves also bear this out still further, for they are to some extent abnormal. The copper occurs, to a degree that it is not at present possible to estimate, in a state of chemical association approaching a copper pyrrhotite rather than chalcopyrite, and this mineral, which has been confounded with chalcopyrite so close is the outward resemblance, is slightly magnetic.

The order of separation of the sulphides, which is constant for all other nickel-copper deposits hitherto investigated, does not appear to be the same, and graphic intergrowths of more than one kind have been observed, while grains of metallics of an alloy consisting of about 66% nickel, 15% gold, over 5% silver, and the balance mainly copper and iron, sometimes occur embedded in the sulphides. The silicate minerals associated with the sulphides are very fresh, showing only rarely slight signs of alteration (hydration) and very limited replacement. There is thus quite clearly a close overall resemblance to the Ural type, where there is no valid reason for doubting the gravitative concentration of the platinum from the magma, the essential difference being the presence of some sulphides along with the rare metals in the basic differentiate.

A relationship between the Insizwa and the Sudbury magmas that is of no small interest in connection with some of the larger and cosmical aspects of particular types of rock magma, their seat of origin within the earth's crust, and the special or characteristic features of the ore deposits peculiar to any given type of rock magma, is found in the fact that the olivine-free norites of the Insizwa eruptive, which occur at the top of the sheet and represent the most acid phase of the differentiation, are practically identical in chemical composition with the bottom phase or basic differentiate of the Sudbury eruptive. The Insizwa is thus a true intermediate type, both as regards parent magma and the character of its ore deposits, between the platiniferous, practically sulphide-free peridotites of the Urals on the one hand and the relatively sulphide-rich Sudbury magma on the other, while the relationship between the Sudbury magmatic type and a granitic magma will be given later.

Before passing to a very brief consideration of the Norwegian nickel-copper occurrences, it is pertinent to draw attention to the fact that the central core arrangement of the ore deposits exhibited by the two occurrences referred to above appears to be the rule rather than the exception for deposits of chromite and titaniferous iron ore in peridotites, and this arrangement is usually regarded as strong evidence of an origin by way of gravitative magmatic differentiation in situ.

The nickel-copper deposits of the Scandinavian peninsula appear to have been derived from gabbroid magmas of varying composition, which on the whole were less basic than the two previous types, but not so acid as the Sudbury eruptive. Moreover, the igneous complexes were for the most part of comparatively small dimensions. It is questionable whether the preliminary marginal concentration of sulphides has in all cases been due solely to gravitative descent. Under the vague and general term "magmatic segregation," as commonly used in current treatises on ore deposits, are included, and incidentally confused, at least three kinds of sulphide transfer, namely, *(1)* gravitative descent, *(2)* a transfer along a temperature gradient, *(3)* transfer along a pressure gradient. In small stocks especially transfer along temperature gradients to margins that may be quite steeply inclined would be particularly apt to occur, so that ore deposits may be developed in positions other than those where they might be expected if gravitative descent were the controlling feature of the preliminary concentration. The mechanism of these other modes of transfer, as well as possible complications introduced by magnetic influences, will be discussed later.

Although there is a good deal of variation presented in the details of the preliminary concentration of the sulphides in the Scandinavian complexes, there is a broad overall similarity of the final consolidation phenomena, as revealed by petrographic study, to those presented at Sudbury, and which have given rise on the one hand to the doubts as to the truth of the gravitative hypothesis and on the other to a variety of theories as to the precise modes of origin of the several deposits. The various Scandinavian occurrences are therefore of considerable interest in the comparative study of magmatic ore deposits since they may be regarded as presenting a series of intermediate types in which gravitative and other influences have interplayed in varying degrees in the preliminary concentration of the sulphides.

General Analysis of Sudbury Phenomena.

The composition of the Sudbury eruptive is given in the subjoined table, together with the averages of 236 analyses of granite of all ages, and 24 gabbros without olivine, and an average computed by mixing two-thirds average granite with one-third average gabbro without olivine, that is to say, the same proportion of acid to basic differentiate as used by Coleman in his computation. It will be seen that the two averages agree fairly closely, and we may regard the Sudbury eruptive as the result of diluting approximately one part of gabbro with two of granite by contemporaneous melting. It is noteworthy that the principal difference between the two averages is in the oxides of iron, particularly in the ferrous oxide, while this abundance of FeO is one of the most striking features of the so-called Sudburites or local greenstones.

TABLE GIVING PERCENTAGE COMPOSITION OF SUDBURY ROCKS, GRANITES, AND GABBROS.

	(1)	(2)	(3)	(4)	(5)	(6)
SiO_2	69·92	49·50	67·86	52·77	62·83	63·11
TiO_2	0·39	0·84	0·45	1·10	0·67	0·54
Al_2O_3	14·78	18·00	12·69	18·49	14·62	15·85
Fe_2O_3	1·62	2·80	1·74	0·28	1·25	2·01
FeO	1·67	5·80	5·07	9·14	6·43	3·05
MnO	0·13	0·12	0·04	—	0·02	0·13
MgO	0·97	6·62	1·16	4·94	2·42	2·85
CaO	2·15	10·64	2·47	7·62	4·18	4·97
Na_2O	3·28	2·82	3·96	2·60	3·50	3·13
K_2O	4·07	0·98	2·78	1·33	2·30	3·04
H_2O	0·78	1·60	1·05	1·26	1·12	1·05
P_2O_5	0·24	0·28	0·18	0·13	0·16	0·25

Column (1) gives the average composition of 236 granites of all periods; (2) the average composition of 24 gabbros without olivine (both sets of figures are taken from Daly's "Igneous Rocks and their Origin" pp 19 & 28); (3) gives the Sudbury acid average; (4) the Sudbury basic average; (5) the Sudbury general average (taken from Coleman's monograph, "The Nickel Industry" p 106, 1913 edition); (6) is an average computed by mixing 2 parts of (1) with 1 part ot (2). Closer agreement between colums (5) and (6) is obtained by taking analyses of norites instead of olivine-free gabbros, but so very few analyses of olivine-free norites are available that it has been considered advisable to use the larger number of gabbro analyses for drawing the comparison. The small amount of Fe_2O_3 present in the Sudbury basic average is noteworthv and significant.

The principal points of the field evidence for preliminary concentration of the sulphides by gravitative descent at Sudbury may be briefly snmmarized as follows: *(1)* The ore-bodies are situated in the neighbourhood of the lower margin of the eruptive; *(2)* gradation between ore and gabbro through the intermediate stage of pyrrhotite gabbro is common, while the pyrrhotite gabbro is typically unfractured and without channels through which the sulphides could have been introduced by circulating solutions; *(3)* the ore-bodies are preferentially associated with the thicker portions of the eruptive and a steeply inclined margin is unfavourable.

There are, however, distinct indications that gravitative descent is not the complete explanation even of the preliminary marginal concentration of the sulphides at Sudbury and this aspect of the occurrences is one worthy of some consideration.

The central core type of segregation, so well exhibited at Nischne-Tagilsk, Insizwa, and in many of the chromite and titaniferous iron ore deposits, appears rather to be associated with basin-shaped igneous masses where the seat of origin is either not situated in the lower central regions of the basins or is of relatively small areal extent. At Sudbury the eruptive is believed to have ascended from beneath a comparatively large area near the middle of the southern range, that is to say, within the lower regions of the basin. It seems doubtful, therefore, whether a central core arrangement is to be expected in the regions in the neighbourhood of the southern range. On the other hand analogy with other large differentiated complexes points to a tendency toward central core concentration, or to put it in another way, to a diminution in the degree of concentration of ore minerals toward the peripheries of the basin. It is commonly believed that enormous quantities of sulphides have been eroded away from the peripheral parts of the Sudbury eruptive without leaving any trace of their supposed former existence. There is an alternative explanation which receives substantial support from the comparative study of other differentiated basin-shaped complexes, namely, that these hypothetical quantities of sulphides to a large extent never existed at Sudbury and that the sometime peripheral extensions of the eruptive were comparatively poor in sulphide concentrations after the manner of those complexes exhibiting central core concentration. There are indeed other indications at Sudbury suggestive of incipient central core cencentration.

If we also take into consideration the probable heat distribution during the cooling period in the case of the Sudbury eruptive on the assumption that the seat of upheaval lay in a relatively large focus situated somewhere beneath the southern range, it seems probable that a maximum concentration of the sulphides would be brought about in the form of a ring or annulus some little way down the sides of the basin by the combined effect of gravity seriously modified by differentiation along temperature gradients toward the cooler margins remote from the focus of upheaval. It will be clear that an even greater preliminary concentration of the sulphides could thus be effected than by the gravitative process alone. The comparative study of magmatic ore deposits of the "gravitative" type, taken in conjunction with the specific evidence in this case, seems rather to point to an approximately annular arrangement of ore deposits within the Sudbury basin rather than to anything approaching a general distribution over the floor of the eruptive or to greater accumulations in the more centrally situated regions of the basin, while magnetic influences, to be discussed later, have also probably played an important part in localizing the sulphide accumulations in the annular zone.

The Principles of Metallography.

Before proceeding to a discussion of the petrographic evidence it will be necessary to present a brief statement of some of the basic principles of metallography, since the controversy between the two schools appears to be primarily due to lack of appreciation of the fundamental principles to be applied in the interpretation of microscopic and petrographic structures. What applies at Sudbury, be it noted, applies in general to the interpretation of these structures.

Metallography may be defined as the study of the internal structure of metals and alloys. The consideration of metals and alloys as a class apart from other mixtures and solutions is mainly an historical accident arising from the great industrial importance of metals and alloys, but the fundamental principles of the science are of general application. It is a branch of physical chemistry, since the internal structure depends on the physical and chemical conditions under which the substances are formed, and the study of structure presents itself as a department of the study of equilibrium in heterogeneous systems. Of the various methods of metallographic investigation that which is known as thermal analysis must be regarded as the *foundation* of all others. This is the point, that is not sufficiently recognized by those who use the term "metallographic" in connection with photomicrographs of polished ore specimens. In the great majority of cases the thermal analysis requires to be *supplemented* by microscopical investigation, while magnetic, electrical, and other methods all find application in special cases and indeed are sometimes indispensable.

It is rarely possible to interpret correctly the results of microscopic investigation without some knowledge of the diagram of thermal equilibrium. The basis of the diagram of thermal equilibrium is the freezing-point curve, but the complete thermal diagram comprises not only this curve but curves representing the composition of the solids separating from the melt and the transformations, if any, undergone by the constituents *after solidification.* It is in fact a graphical representation of the dependence of the number and nature of the phases possible to the system when in equilibrium on the composition and temperature.* It is important to add that for geological purposes this last statement must be amplified so as to include some knowledge of the equilibria within the systems in temperature regions well above the freezing-point curve. This further development of elementary metallographic principles is of fundamental importance to geological science on account of the almost invariable presence of gaseous phases in the systems, *which are apt to appear in quite different forms on solidification of the melts.*

Again, owing to the enormous masses of material involved, we must extend these metallographic principles further and say that it is often impossible to correctly interpret macroscopic and field structures without some knowledge of the conditions of thermal equilibrium, while the structures developed in the neighbourhood of igneous contacts present special difficulties arising partly from the presence of gaseous constituents in the melts and partly from the peculiar thermal conditions that prevail in the region of an igneous margin during the progressive stages of the cooling process. (See "The Mathematical Theory of Heat Conduction," by Ingersoll & Zobell, pp 128–9).

Application of Metallographic Principles to the Study of Rock Magmas.

If experience proves so conclusively, in the case of the cooling phenomena presented by comparatively small masses of such relatively simple systems as the ingots, billets, or ladles of metals or alloys encountered in industry, that it is only rarely possible to correctly interpret the results of microscopic investigation without recourse to the methods of thermal analysis, it follows, a fortiori, that in the case of cooling rock magmas, where the complexity or heterogeneity of the systems, the quantities of the reacting substances, and the cooling periods are one and all magnified to an enormous degree, we cannot reasonably hope to attain even a correct approximation of the significance of the petrographic structures without recourse to the methods of thermal analysis. It will be equally obvious to any thoughtful and well informed student of the modern literature of ore deposits, both in regard to many of the field structures and those exhibited macroscopically and microscopically by polished sections of ores derived from igneous magmas, that the paramount necessity for applying the methods of thermal analysis is almost invariably overlooked by the numerous writers on the subject. Instead of a broad treatment of the structures presented from the equilibrium standpoint the first elementary principles of sound scientific treatment are ignored, and the structures are merely discussed from the narrow and ineffective viewpoint of solutions. One very common result of this deplorable narrowing of the physico-chemical outlook on the problem of ore derivation from igneous magmas is the postulation of successive solutions in cases where there are no valid reasons for any such assumption, while another is a general vagueness in conception of the ore-forming processes, and to such an extent in this the case that the theories promulgated are often too mysterious either to be clearly comprehended or usefully applied to the practical solution of the problems of metal mining. Yet another result, typified in the case of the Sudbury deposits, is acute controversy between the petrographer and the field geologist not merely on minor issues but on larger matters of basic significance. The development and adoption of sound systematic methods of attack for interpreting the petrographic evidence furnished by ore deposits is therefore not a mere matter of academic or scientific interest, but is one of world wide industrial importance on account of its potentialities as an aid to the discovery and economic exploitation of mineral deposits.

Now it is obviously quite impossible to construct the diagram of thermal equilibrium for a vast mass of rock magma, such for instance as the Sudbury eruptive, by the direct experimental methods used in metallography. At first sight therefore the problem of successfully determining the significance of the petrographic structures presented by ore deposits may seem well nigh a hopeless one in view of the foregoing statements. But although it may not be possible to construct thermal diagrams for such masses with the precision attained by the metallographer, it does not seem at all impossible to obtain some very useful ideas as to what are probably the more salient features of some of the equilibria that are of special importance in the derivation of ore deposits from igneous magmas if we apply some of the fundamental principles of physics and chemistry in as thorough-going a way as may be possible in the present state of development of these basic sciences. In other words we may by indirect analysis acquire the more important elements of that "some knowledge" of the thermal diagram which is to a greater or less extent indispensable for the interpretation of the structures.

*This very brief summary is paraphrased from the opening chapters of "Metallography" by C. H. Desch.

There are certain broad well-established principles to be borne in mind when considering the cooling phenomena presented by a mass of molten rock. (1) When the melt is cooled sufficiently it passes eventually from the liquid into the solid state. This change is a reversible one, for the solid can be remelted by adequately raising the temperature. The principle of "mobile equilibrium," enunciated by Le Chatelier, is therefore applicable. The principle may be stated as follows: When a factor determining the equilibrium of a system is changed, the system tends to change in such a way as to oppose and partly annul the alteration in the factor. (2) A cooling rock-mass may also be regarded as a complex solution, mixture, or system in which a variety of chemical reactions may occur during the cooling process. A principle enunciated by van't Hoff is also applicable therefore. This may be stated as follows: The directions of chemical processes which result in equilibrium vary with variations of temperature in such a way that the lower the temperature the more is equilibrium established with the production of heat. Combining these two principles we may infer that the directions of the chemical processes occurring in a rock magma at temperatures remote from the freezing range will be of such a kind as are accompanied by a minimum of heat production, while as the temperature falls the tendency will be for the reactions to become strongly exothermic, while such changes may be expected to take place within the mass as will tend to oppose the change from the liquid to the solid state.

Magmatic differentiation, whether produced by partial crystallization, separation of non-consolute drops, local depression of the freezing point by molecular transfer, or osmose, thus appears as a result of the successive efforts of the magma to oppose or prolong the general change from the liquid to the solid state with fall in temperature.

The Effects of Hydrogen and its Compounds in Rock Magmas.

While the stability at high temperatures of the lower sulphides of iron, copper, etc., and their insolubility in anhydrous silicate melts is the basis of matte smelting, it is commonly thought that the presence of water, or the elements of water, in igneous magmas coupled with the solubility of all substances to a greater or less degree in water at high temperatures, makes it improbable that these sulphides can separate in igneous magmas in a manner comparable with their behaviour in artificial anhydrous melts. It is necessary therefore first of all to consider the constitution of rock magmas from this viewpoint. The ability of metals to decompose hydrogen oxide at high temperatures with the production of free hydrogen is one of the commonplaces of chemistry. Ferrous oxide also possesses this property to a marked degree, while both ferrous and ferric oxide are always present in igneous rocks though the proportions and total quantities vary between wide limits.

The reaction $2\,FeO + H_2O \rightleftarrows Fe_2O_3 + H_2$

is easily reversible, and it is highly significant that it matters not which direction the process takes it is accompanied by little or no evolution of heat at magmatic temperatures since the heat of formation of water, 68,360c, and that of FeO is almost the same, while the addition of an atom of oxygen to 2FeO to form Fe_2O_3 is accompanied with the same evolution of heat as accompanies the formation of FeO; also FeO tends strongly to oxidize to higher oxides at moderate temperatures in the presence of bodies capable of furnishing the necessary oxygen. The effect of the presence of the two oxides of iron in molten magmas is therefore to convert part of the water returned as such in an ordinary rock analysis into free hydrogen. Further, since this process can be conducted reversibly and almost isothermally, while both the RO and R_2O_3 molecular types are abundantly represented in all magmas by other oxides, CaO, MgO, Al_2O_3, etc., it affords one of the most ideal and delicately balanced chemical contrivances imaginable for varying the concentration of free hydrogen in a magma to meet changing temperature, pressure, or other equilibrium conditions. There seems no room for doubt also that this reaction, by maintaining free hydrogen in the melt, plays an extremely important part in the chemical mechanics of magmatic stoping and igneous injection generally, together with the collateral metamorphism so commonly produced in the neighbourhood of igneous contacts.

Viewed in conjunction with the chemical peculiarities of the Sudbury magma, to which special reference has been made, this reaction is full of suggestion in regard to the great and fundamental problems of vulcanism. If the facts are examined carefully it will be seen that the process of injection of the Sudbury eruptive can be explained as a result of the escape of occluded hydrogen gas together with some sulphur gas from an inner zone of metallic iron containing some nickel, that is to say, metal similar to an ordinary meteorite in composition. As a result of the evolution of the gases small quantities of Fe and Ni would tend to be carried into the outer shell of slag, the iron reacting with Fe_2O_3 to produce FeO. Such escape of occluded gases tends to occur in the ordinary course of cooling metals and is, of course, the cause of the "blow holes" which are apt to give serious trouble in steel metallurgy, while it is well known that hydrogen is a gas that can be occluded in immense quantities by certain metals.

In marked contrast to this mechanism of igneous injection, which may be described as hydrogen stoping, is that of the Insizwa where secular cooling locally buckled the outer crust and rent it asunder, an almost gasless but very basic magma being quietly poured out along the rents. It is noteworthy, however, that these two extreme types of volcanic mechanism both have their origin in one prime cause, namely, the secular cooling of the earth and the physico-chemical consequences of diminishing temperature. It is also of interest to observe and compare the essential differences in character and content of the ore-bodies generated under the two sets of conditions.

The presence of quantities of free hydrogen in rock magmas is amply confirmed by the phenomena presented by volcanic eruptions as well as by analyses of the gases occluded in solidified igneous rocks. The effect of hydrogenating the melt in this way will clearly be to depress the freezing point and diminish the viscosity greatly below what would be the case if water alone were present. The chemical mineralogy of the rock-forming minerals indicates that the silicates present in an igneous melt are highly associated systems, while hydrogen and its oxide are small simple non-associated molecules at elevated temperatures. Although the percentage by weight of water shown in a rock analysis is a small one, the ratio of the number of gaseous molecules to that of silicate molecules will be high in the melt and the necessary conditions for great depression of the freezing point and low viscosity are therefore fulfilled despite what at first sight would appear to be inadequate quantites of the gaseous constituents. The fluidity of an igneous magma is thus of a rather different order from that of such a substance as water or molten anhydrous silicates, since it arises primarily from the extreme differences in the molecular sizes and physico-chemical properties of the constituents. It can perhaps best be conceived as the motion of large and heavy spheres, the silicates and their congeners, moving with respect to one another on small light, pneumatic ball-bearings, the small gaseous molecules, thus producing a melt of much diminished internal friction. Aquo-igneous fusion is clearly a poor and incomplete description of the phenomenon, since the unique gaseous energy of free hydrogen probably plays as great or perhaps an even greater part than that played by its oxide, water, while in many magmas other gases such as CO_2, fluorine compounds, etc., appear to have played an important part not only in promoting fluidity but in stoping the melts into position. In the case of magmas containing an excess of silica over base, such as granite, it seems not improbable, too, that practically the whole of the H_2O appearing in the rock analyses may have been dissociated into hydrogen and oxygen by catalytic action of the free silica, though it must be admitted that this is a far more difficult matter to establish.

In connection with this conception of the fluidity of rock magmas it is well worth while to compare the phenomena presented in the roasting of pyritic concentrates and many simple ignitions commonly performed in the laboratory. At certain stages in these operations the particles glide over one another with such remarkable ease as to convey the impression that the mass is a very free-moving liquid. Yet in reality it is a case of relatively large solid particles moving with respect to one another by the intervention of intercalated gases. Under conditions where the large solid particles are replaced by small liquid systems it is probable that a very much smaller proportion of gas would produce similar results.

In the light of this piece of thermal analysis it is easy to understand many of the phenomena of magmatic differentiation, also the ease and rapidity with which the transfer of large heavy molecules, or even larger systems such as crystals or non-consolute drops, may take place, while the viscosity of igneous magmas may often be very much less than that of water itself. There are cogent reasons, based on metallographic studies, for thinking that many of the phenomena of magmatic differentiation are effected in amazingly small intervals of time at temperatures very close to the freezing range. It will be obvious that an important effect of great depression of the freezing range is to compress the actual freezing phenomena into a relatively small temperature range. It will also be clear that the melting temperatures of minerals and rocks will differ widely from their probable consolidation temperatures in or from an igneous melt and will be in general much higher; also that the experimental results obtained by crystallizing anhydrous silicate melts must be applied with great caution in the interpretation of the phenomena of magmatic differentiation.

In view of the zeal with which the theories of gravitative control and crystallization differentiation have been advocated as the principal factors in magmatic differentiation, it is worth while noting that the most acid differentiates, the olivine-free norites, in the Insizwa sheet, which is often cited as a striking instance of gravitative differentiation by the sinking of olivines, are of appreciably higher specific gravity than the more basic olivine-bearing rocks situated immediately below them. Although crystallization differentiation and gravitative descent have formed an important part of the differentiation process, upward molecular transfer to a cooling margin is also indicated, and the comparison of the rock analyses indicates that upward molecular transfer has likewise taken place in the Sudbury sheet and forms an integral part of the general process of magmatic differentiation in these two instances.

Sulphur and the metallic sulphides react with H_2O at elevated temperatures in much the same way as the metals, decomposing it with the production of H_2S, the reactions being, as usual, reversible and subject to the general laws governing reversible reactions. The heat of formation of H_2S is only one-twentyfifth that of H_2O, while the heats of formation of the mono-sulphides of the ore-forming metals are in general about half of those for the corresponding oxides. Elemental sulphur and the dissociable sulphur of the ore minerals such as pyrite, chalcopyrite, etc., are easily converted into H_2S by H_2O at elevated temperatures, but the non-dissociable or matte sulphur of the lower sulphides is held with much greater tenacity or chemical affinity. Considering then the cooling curve of a rock magma containing sulphur, the early formation of both H_2S and the mono-sulphides of the ore metals may confidently be asserted, while the presence of H_2S in rock magmas at high temperatures is abundantly confirmed by the phenomena presented at volcanic vents as well as by analyses of the gases occluded in igneous rocks, although it does not appear either as a constituent of ore-bodies or in an ordinary rock analysis. It follows as a corollary from the constitutions of such ore minerals as pyrite, chalcopyrite, etc., and the chemical reactions and principles which have been cited, that over an intermediate temperature range the lower sulphides will be present coexisting with gaseous H_2S. It is important to consider both the distribution of H_2S under these conditions and the possible solvent action of water on the sulphides.

The solvent action of water increases greatly with rise of temperature, but the solvent powers of a substance for a solute are apt to be diminished almost to vanishing point by sufficient dilution with an inert solution. Strong vitriol, for instance, is a most powerful solvent and corrosive; dilute it sufficiently with water and its solvent powers are greatly diminished, while practically complete protection can be obtained for one substance or set of substances by introducing either a more soluble substance or series of substances or substances capable of uniting with water. These are the conditions that prevail in an igneous melt in regard to the sulphides. It must not be forgotten that all the basic oxides present in an igneous melt are capable of uniting with water to form hydroxides. Many of these are to some extent stable at elevated temperatures provided there is an adequate opposing pressure, as is clearly shown by the compositions of such minerals as hornblende, the micas, etc. At temperatures in the neighbourhood of the freezing range therefore the chemical probabilities are all in favour of the small quantities of water present in more or less deep-seated magmas being sensibly attracted toward the vastly preponderating masses of mixed oxides or silicates and thereby deprived of any serious solvent action on such bodies as sulphides, until a very late stage in magma consolidation is reached. The significance of this will be discussed later in explaining the final escape of magmatic waters and the accompanying re-solution of the disseminated traces of sulphides and other substances. At temperatures remote from the freezing range water as such scarcely exists in igneous magmas, since it is broken up into free hydrogen and the oxygen is either free of otherwise combined.

On the other hand, although the mono-sulphides of Fe, Ni, Cu, etc., are slightly soluble in melted silicates at high temperatures, as the temperature falls the solubility diminishes. The net result of greatly lowering the freezing range of the melt by combined hydration and hydrogenation, is to render the minute quantities of sulphides present in an igneous melt even more insoluble before the consolidation temperature is reached than would be the case in an ordinary smelters' slag. Again, the hydrogenation of the melt, as a matter apart from hydration, tends to maintain its viscosity at a low value close down to the consolidation temperature, while the effect is commonly accentuated by the presence of other gases such as CO_2, etc. There is a good deal of evidence to indicate that dehydrogenation is not complete until after consolidation of the silicates, which is, of course, only the natural ultimate extrapolation of the consolidation law of decreasing basicity.

It is probable therefore that the beautifully adjusted natural magma is far better constituted for the concentration of minute quantities of insoluble sulphides by gravitative descent and other methods of transfer than the crude slags of the smelter. It certainly seems reasonable to suppose that Old Dame Nature should employ the most refined metallurgical methods, and the study of ore deposits from the genetic standpoint thus presents itself as one of considerable interest not only to the miner and mining geologist but especially to the metallurgist.

(To be continued)

SIAMESE MINING LAWS.

We are asked occasionally for particulars of the mining regulations in Siam. The latest enactments were made in 1901. As copies of the full text are unobtainable in this country, we give herewith the main provisions of the Act. For this information we are indebted to the Siamese Minister in London.

GENERAL. — All lands and all metals and minerals within the Kingdom of Siam and its dependencies are Crown property, and no title under which any land is held for building or agriculture or for any purpose other than that of mining or prospecting shall convey any right over the metals and minerals contained in such lands. If an applicant has no document of title, but the Government has no objection to allowing the applicant to work the mine in question in the future, the Royal Department of Mines can order the applicant to apply for a mining lease within ninety days of receiving notice from the Department of Mines.

APPLICATION FOR MINERAL WASHING LICENCES.—Applicants shall apply personally to the superintendent of mines or other duly authorized officer. A Mineral Washing Licence may be granted on payment of the prescribed fee and shall confer the right to wash for minerals on any unoccupied land within the place specified in such licence for the space of one year from the date of issue. If the holder of a Mineral Washing Licence break any of the rules he shall be liable to a fine not exceeding 20 ticals for each offence, and his Mineral Washing Licence shall be forfeited and he shall pay all royalties according to the law for the time being. A Mineral Washing Licence shall be personal and not transferable, and shall cover no one in the employ of the holder, and must be produced when called for by an officer.

APPLICATION FOR PROSPECTING LICENCE.—Application is to be made in writing. The area shall be limited to one or several amphurships as the officer shall think fit. The holder has the right to prospect on unoccupied land within the muang or amphurships specified for the period of one year, and can apply for a renewal at the end for not more than one year at a time; fees to be paid in advance. A Prospecting Licence is personal and not transferable and does not cover persons in the employ of a licence holder.

APPLICATION FOR EXCLUSIVE PROSPECTING LICENCE.—Application is to be in writing to the proper officer. An Exclusive Prospecting Licence conveys the same rights as a Prospecting Licence except that no other than the holder and his servants shall have any right to go in and prospect in the area included in such licence. The holder may apply for another licence for not more than one year. The fee is to be paid in advance. Before sending in an application he must stake out the prospecting area he intends to apply for and make a reasonably accurate plan of it, which shall be verified by the Governor or Amphur of the district, who shall certify in writing whether such land is unoccupied or not, and whether anyone is owner of or has any right over it. A plan is to accompany the application. The maximum area is 3,000 rais.

APPLICATION FOR MINING LEASE.—The application is to be in writing, and must be accompanied by the prescribed fee and by as full a report as circumstances will permit, and by a reasonably detailed map and by good average samples of the ores. Each application must have the certificate of the Governor of the Province that the area is not already occupied for mining purposes, with the names, if any, of the owners of the ground. The applicant must show to the satisfaction of the Governor that he has sufficient capital to work the concession properly. Every mining lease, after receiving the King's sanction, shall be signed and sealed by the Minister, without which it shall not be valid. The sealing fee is 50 ticals on each Mining Licence. Terms shall not exceed 25 years. The rent is payable half-yearly in advance at the rate fixed in lease. Royalties payable are as fixed by law for the time being or as specified in the lease. Survey and demarcation must be done within twelve months of signing the lease if the Government undertakes the survey, the applicant to pay the cost. The survey shall be plotted to the true north on a scale of 1 in 2,000, showing all lodes, buildings, waterways, shafts, and other surface works, giving the names of the surface occupiers, and to be subdivided into rectangles of 10 rais, each numbered for reference.

LEASES.—The area shall be demarcated by boundary posts with survey numbers corresponding to the plans, clearly chiselled on the sides and to be kept in good repair. The extent of each mining area shall not exceed (a) 100 rais on a lode, (b)300 rais in the case of alluvial, coal, or iron mines and quarries, unless the King sanction larger areas; the area to be rectangular and the length not more than three times the breadth. A report is to be forwarded once a year to the Superintendent of Mines, giving the amount of all metals and minerals produced, number of working days, daily average of labour employed and, if called for, an accurate plan of the workings. Every lessee shall forward to the Superintendent of Mines copies of all published reports and, if a company, of its prospectus, memorandum of association and articles of association. Every mining area shall be actively worked by not less than the number of bona fide workmen specified in the lease without intermission of more than six months in any year or twelve months in any two years, unless exemption from work shall have been granted in writing by the Royal Department of Mines. Any lessee may apply for exemption for not less than three years, and, if granted, shall pay the fee in advance, which fee shall be in addition to rent payable under the lease. A lease can be surrendered, by giving notice in writing, six months after receipt of such notice by the Department of Mines, unless an earlier date be mutually agreed. When a lease is determined, notice shall be given by the Royal Department of Mines in the Government Gazette, when the lease shall return to the Royal Department of Mines. Buildings, sheds, machinery, tools, &c., must be removed within six months from determination of lease, and any ore mined must be removed within six months, or if not removed, shall be so stacked by the lessee on ground as not to interfere with the working of any future lessee.

TRANSFER OF MINING LEASE, &c.—Every lessee and every holder of a prospecting licence or an exclusive prospecting licence must have a registered address within Siam, at which all notices shall be served. If a holder loses his licence a new one will be forwarded on payment of a fee. No transfer of a Mining Lease is valid unless signed and sealed by the Minister. Application to transfer is to be made to the Royal Department of Mines, the transfer to be effected as follows: The lessee and transferee must come together either personally or by duly appointed agents to the Royal Department of Mines, and bring all their documents of title with them. A document of transfer of the lease is to be made in triplicate; one to be kept by the Royal Department of Mines, and one each to go to the transferor and transferee. The lessee must pay all the prescribed fees; he shall also pay any sums due on the lease at that date before transfer can be made. A lease terminates by the death of the lessee or liquidation of company. The successors must apply to the Royal Department of Mines within ninety days if they wish to continue work. No mortgage or charge on a mining area will be recognized unless previously sanctioned by the Royal Department of Mines. No lessee may use his lease to pay debts, nor can his lease be attached for his debts. A lease is determined if the lessee become bankrupt.

WORKING OF MINES.—A mine must be under the control of a competent manager, whose name shall be made known to the Royal Department of Mines by the lessee. The lessee may cut and use timber for mining purposes, subject to the forest laws, local or otherwise, in force. A mining lease does not give ownership of land. The lessee has the exclusive right to mine all metals and minerals on unoccupied land in his area. The lessee has the right to take such unoccupied land as he may need for houses, sheds, vegetable garden, or keeping animals necessary for working mines, and supporting his coolies, if written permission from the Superintendent of Mines be given. Officers of the Royal Department of Mines have power to inspect workings. Proper and accurate books are to be kept showing the number of employees and quantities and character of metals extracted and dealt with. The lessee shall keep at an office in his area detailed maps showing surveys, plan of his area and all underground workings; such plans on the determination of lease shall be corrected up to date and sent to the Royal Department of Mines in order that these plans, &c., may be used for the same mine again. The lessee shall keep levels, shafts, and works in safe condition. All fossils and archeological specimens shall be furnished to the Royal Department of Mines, with description of the conditions under which they were found. All abandoned shafts shall be securely fenced.

WATERWAYS.—The Government reserves control of all waterways. Every mining lessee has prima facie right to draw and use all water on and under his area, subject to these clauses. Diversion of waterways requires the written consent of the Superintendent of Mines, and permission will be refused if they will interfere with or damage the water supply of any neighbouring mining area. Applications for leave to divert must be accompanied by a plan on the scale of 1 in 2,000.

RULES FOR DISPOSAL OF TAILINGS.—Tailings must not be disposed of as to damage any waterway, nor so as to float on to or be heaped upon any unworked metalliferous or agricultural ground or roads or private premises. In case of alluvial works the lessee shall, wherever possible, throw his overburden behind his working face on worked-out land. The lessee shall not contaminate water in use for domestic or irrigation purposes with any poisonous minerals.

RIGHTS OF WAY.—Mining areas are subject to all existing rights of way, water, and other easements. The lessee may construct roads on his area after obtaining permission of the surface occupier, if any, and may obtain permission for roads outside his area by application to the Royal Department of Mines.

MISCELLANEOUS.—If a lessee discover minerals on his lands other than those for which he has the right to work, he must forthwith report the same to the Royal Department of Mines and may make application for leave to work them, subject in default to a fine not exceeding 800 ticals for each offence. The Government reserves the right to take road materials, also to take or authorize others to take timber, charcoal, gums, and other natural produce from unfelled forests and from uncleared land within the area, and to take plots of land for police stations, roads, and canals on payment of proper compensation, but the lessee shall receive no compensation for the value of minerals underground resumed by the Government. No mining or prospecting work is to be carried on within 20 wah from any properly demarcated mining or prospecting area, or from any highway, waterway, or buildings, or within 500 wah from any fort or other naval or military work, under a fine of 800 ticals for each offence. Unless the sums due by a lessee to the Government are paid within 90 days of demand by duly authorized officers of the Royal Department of Mines, a lease may be cancelled. Overdue amounts are charged five per cent per annum. The decision of the Royal Department of Mines in all disputes between neighbouring lessees shall be final. Sending by post of any notice to the duly registered address of the holder of any mining lease or licence shall be taken to comprise due service on the addressee.

DEFINITIONS.

Mine Washing Licence is a licence granted by the Royal Department of Mines, conferring on the holder the right to wash metals and minerals.

Prospecting Licence is a licence granted by the Royal Department of Mines, conferring on the holder the right to search for metals and minerals over a specified Amphurship or Changwat.

Exclusive Prospecting Licence confers the exclusive right to search for metals and minerals over a specified area.

A Prospecting Area is an area of land, including land covered by water and its vertical extension below the surface, in which an Exclusive Prospecting Licence confers the exclusive right to search for metals and minerals.

Mining Lease is an indenture of agreement between the Royal Department of Mines and any person, by which the holder of the lease is empowered to carry on mining work within the area specified by the lease.

Lode is any seam, deposit, vein, reef, dyke, or blow containing metals or minerals other than alluvial ground.

Alluvial Ground is any loose rock or stone, gravel, sand, soil, or earth from which metals or minerals are ordinarily obtained by washing.

To Mine means to deal with any lode or alluvial ground by any mode or method of working whatsoever for the purpose of obtaining therefrom any metals or minerals.

Unoccupied, when applied to land, refers to any land which is not occupied by buildings or gardens, nor in use, nor in preparation for use, for any agricultural or industrial purpose, nor reserved by local custom for any purpose when such land shall have been declared by the Government to be unoccupied within the meaning of this Act.

Muang, Province or District. *Changwat*, District or Circle. *Amphurship*, Headmanship or Police District. *Wah*, One fathom; equals 2 metres. *Sen*, 20 wahs. *Rai*, One square sen.

LETTERS TO THE EDITOR

The Accuracy of Chemical Balances.

The Editor:

Sir—I am much obliged for your reference in the current number of the Magazine to my paper on the accuracy of chemical balances, read before the Chemical Society. I will deal with the various points raised by you. The immediate test that was being made was the comparison of standard weights, one in each pan of each balance, of the same size and material. The balance cases were kept closed throughout the whole series of experiments. It was not desired to have the balances adjusted, as experiment shows that it takes some days or longer for the balance to "settle down" after adjustment, and moreover the whole object of my experiment was to obtain a balance which should be constant in its indications without adjustment over a period of at least three months, and this apparently the balance makers cannot do. You are quite right in supposing that the standard weights never left the pan during the whole set of tests. The fact that I used plus or minus signs means that the difference in weight in the case of each balance was at one time on the right and one time on the left of the neutral line. Although you state that you have read the paper several times, you seem to have missed the paragraph on the top of the second page. The weighings "were too many to record in full, and only those representing maximum and minimum variations are recorded." I think this explains why you only found alternate plus and minus figures.

I think I may assure you that I have studied most carefully all the causes which you are good enough to suggest, and am afraid that I am still not in a position to obtain from the makers a balance of the requisite constancy, and repeat that it behoves them to turn out such an instrument mechanically dependable.

BERTRAM BLOUNT.

76-8 York Street,
Westminster, December 31.

What are Ore Reserves?

The Editor:

Sir—With regard to your note in November on Kyshtim reserves and your editorial on the subject in the December issue, the Kyshtim engineers assumed that it was merely by inadvertence that the figure for "ore ready for stoping" had been given this interpretation by you. Your editorial in the December number of the Magazine makes it appear that you intentionally changed the wording of the Kyshtim circular, and against this editorial licence I must protest in the strongest way possible. Your November note gave the impression that you were quoting from the Kyshtim report and, when you said "an estimate of the ore reserves is as follows . . . . a total of 395,416 tons," your readers would take that as being on the authority of the "Kyshtim engineers." So far frcm quoting from the report you were actually modifying that report to make it square with some ideas of your own. Surely if you felt it incumbent upon yourself to differ, your course was to say so openly and not to make the "Kyshtim engineers" appear to say something they had no intention of saying.

As a matter of fact the Kyshtim "ore ready for stoping" is not at all equivalent to what you consider to be properly ore reserves; the phrase is rigidly descriptive, and connotes blocks of ore, with levels, rises, and shoots all completed and the pioneer stopes started. What the reserves would be on your basis, I have not the slightest idea, but certain it is that they would be much larger than 395,416 tons.

Reverting to the broader aspect of the question touched on in your editorial in the December issue, your reference to the Rand shows clearly that quartz gold mines were in your mind, and that you do not differentiate between different classes of ore-bodies. Had you paused for a moment you could not have failed to remember that the porphyry coppers rely upon bore-holes results almost exclusively for determining ore reserves, and so saved yourself from the error you have fallen into by saying that the restriction of the word "reserves" to the ore blocked out "is on the whole the current practice." So far is this from being the truth that it is safe to say that the tonnage of ore determined by bore-holes, which responsible engineers with world-wide reputations class as ore reserves, exceeds many times the tonnage blocked out by drives and rises. I suppose you would hardly maintain that Utah Copper, or Braden or Chuquicamata have no ore reserves and yet your argument would lead to that. The fact is that the porphyry coppers are *sui generis*, as are pyritic bodies like those of Kyshtim, Mt. Lyell, and Tennessee.

I cannot burden this letter of expostulation with all the pertinent facts that go to prove this contention, but as one of the engineers responsible for the Kyshtim figures I wish to emphasize the point that any engineer who, having to do with a well-studied pyrite body, should ignore the definite facts disclosed by bore-holes and restrict his ore reserves to ore blocked out, would have failed in his position of trust.

R. GILMAN BROWN.

7, Gracechurch Street,
London, E.C.3, January 2.

Auditing.

The Editor:

Sir—Now that the war has tightened our resolutions, and made us desire to improve our financial methods, the time is ripe, in my opinion, to remove a lot of the humbug that too often is associated with the affairs of mining companies. As a first step in the right direction I suggest than an endeavour be made to insist that the directors of mining companies should issue annual reports complete in themselves and truly reflecting all that is known of the particular mine.

It was my privilege to attend, as a shareholder, the last two meetings of the Burma Corporation, and I was faced by a board of directors who, having issued reports that were intelligible, came prepared also with a model of the mine and a plan of the workings, and moreover were competent and willing to answer any, and every question, technical or financial, which any shareholders cared to ask.

On a more recent occasion it was my misfortune to attend as a dissatisfied shareholder at the annual meeting of another mining company, whose directors I had formerly attempted unsuccessfully to induce to issue a sketch showing the work done and contemplated, so as to make the report intelligible. On this occasion I criticized various matters at length, asked several questions, and pressed for sketches showing the work done and contemplated, and for such other information as would enable shareholders to judge of the probable value of the property, which had depreciated in market valuation to the extent of £1,200,000 during the last three years. The result was that the directors put up one of their number to reply: this he did to the effect that I had taken them by surprise and as my speech dealt with matters which were somewhat complex, and raised the question of a number of percentages, they would be glad to have a copy of my speech so that they could deal with it in extenso. The number of percentages given was ten; two only of these were referred to particularly. Some days subsequent to the meeting, after the board had had an opportunity of reading a report of my remarks and comprehending the nature of the points upon which I had suggested that more information might have been given, I received a letter of six pages, consisting of a dissertation on mining methods in general and not at all germane to the issue; in addition, I received a ludicrously wrong "explanation" as to how the assay-value of ore fed to the mill might be calculated. The whole thing amounted to what might be called more or less stereotyped "flapdoodle" such as is often fed to shareholders at annual meetings.

I may mention that, though a typed copy of my remarks was supplied to the reporter present, only a considerably abbreviated account of my speech was issued to the shareholders, although a number of those present at the meeting had expressed their appreciation of my criticism. The parts cut out of my speech were adversely critical. I am writing to catch the ear of men who understand, so that further criticism on these lines is unnecessary.

The foregoing may be considered destructive, now for something constructive.

What I have to suggest is that a "technical auditor," who should be an independent mining engineer with a good knowledge of modern economic geology, should be appointed by shareholders of every mining company. The technical auditor should be required to do such work as is necessary to certify under the annual report of a mining company that he has examined the assay plan of the mine, the records of all diamond-drilling carried out, has received all information and explanations asked for, is satisfied that adequate but not excessive development and exploration work has been carried out, and that the report exhibits a true and correct view to date of the value and condition of the mining property. In short he will in effect certify that not only the truth, but the whole truth has been told in the report.

It is considered necessary that an auditor should examine the books of a company and certify that he has obtained all information and explanation required and that the balance sheet is drawn up to exhibit a true and correct view of the state of a company's affairs. It is possible to juggle with accounts which are fairly well understood of all men; how much easier is it to juggle or make mistakes with assay plans, development results, diamond-drill borings, the probable life of a mine, and other technical matters that even to-day are rarely understood by more than a small percentage of shareholders. If the ordinary auditor's work is worth 100 guineas, the technical auditor's work would often be cheap at 500 guineas.

I have not forgotten the consulting engineer, but I have no quarrel with him; let him remain where he is, and carry out the excellent work done by him in the past. The consulting engineer, whether nominally so or not, is essentially the right-hand man of the directors or of the controlling house, and the duty of the technical auditor should be to serve every individual shareholder alike, irrespective of the number of shares he may hold.

Might is not right, and the small shareholder, often, too often perhaps, has more money invested in mines than he or she can afford to lose.

My suggestion of a technical auditor is not aimed at preventing the control of affairs by larger shareholders, but at preventing unfair control by such. Such unfair control has often so nearly approached vulgar swindling as to be indistinguishable therefrom by all but those who are responsible. I do not seek to minimize the legitimate risks of mining, nor to detract from its often agreeable surprises, but I strongly object to the practice of mixing up all the uncertainties of all types of ore deposits and serving out in general terms what is often not at all applicable to the particular deposit under consideration for the simple purpose of acting as a kind of a smoke screen to hide the shortcomings or the movements of "insiders."

Technical auditors would not kill speculation; they would revive or generate confidence in mining, and there would still be room for intelligent anticipation with all its ups and downs and thrills.

STEPHEN J LETT.

London, December 27.

Issuing Shares at a Premium.

The Editor:

Sir—In last month's editorial, under the heading "Issuing Shares at a Premium," you assume certain difficulties and disadvantages and offer advice as to the manner in which these may be obviated. You say that companies having liberal cash resources should pay for extensions of operations by their means instead of issuing new shares. But can this be laid down as a hard-and-fast rule? If the liberal cash resources are accumulated profits, they rightly belong to the shareholders as dividends, for it must be borne in mind that the majority of mining companies pass through a long and unremunerative development stage and that, other conditions being favourable, dividends should be distributed at the earliest possible date, to those who have waited so long. Should the company desire to extend operations, it is reasonable to assume that such extensions will bear capitalization, and if there is anything in your suggestion that the nominal capital should approximate the actual and real value, it would be better to finance extensions by means of new issues of capital. This permits each shareholder to decide whether he will keep the dividend received by him on his investment or re-invest it in the company by acquiring shares in a new issue. In making a new issue, the company is selling a part interest in the undertaking, and it is only good business to sell at the highest price, that is, by issuing shares at a premium.

You further advise that new companies with no cash should arrange their nominal capital on a scale commensurate with the prospects. As a rule the shareholders in a company with no cash need not worry about prospects. But how, and by whom, will the prospects be defined? When engineers differ as to what may be included as "ore reserves," it would be difficult to find many in agreement as to the capital value which may be placed on a mine for the purpose of share valuation. And what of other prospects? It is hard to imagine a board of directors meeting in solemn conclave to consider the returns of ore reserves and the reports from the geological department (which often hold out more prospect than the ore reserves) with a view to appraising the value of the enterprise in order from time to time to re-arrange the nominal capital on a scale commensurate with the prospects. And what of depreciation, amortization, sinking fund, etc., apart altogether from the eternal questions of working costs and metal prices? He would indeed be a brave man who attempted to define a standard of valuation for the purpose of periodical adjustment of the nominal capital.

But what practical business man worries about the nominal or par value of a share? There are two values which interest him: the intrinsic value and the market value; and if a share intrinsically worth £2 is quoted on the market at £1, it is immaterial whether the nominal value of the share is 5s. or £5.

J. P. B. WEBSTER.

7, Gracechurch Street, London, E.C.3.,
December 20.

NEWS LETTERS.

CAMBORNE.

EAST POOL & AGAR.—For some time past the eastern drive on the Rogers lode at the 190 fm. level has given disappointing results, but it now appears that this level has not been driven on the main section of the lode. Recently, a bore-hole was put out north 94 ft., and from 45 to 73 ft, a channel of ore was passed through, assaying 32 lb. of black tin per ton, and this is regarded by the management as probably a faulted section of the Rogers lode. A cross-cut will be driven to test this section of ore ground, aud if the core values are maintained on development, the discovery is clearly a very important one, seeing that there is a large extent of virgin ground to the east of the existing workings on the Rogers lode. It is rumoured that, owing to the pressure of the Government, there may be expected a speedy and substantial increase in the mineral returns, and this presumably will be brought about by increasing the tonnage from the Rogers lode, with its high average values, and decreasing the quantity of ore mined from the East Pool section, where the average values are much lower. In other words, to meet national necessities, it would appear that the eyes of the mine will be picked to some extent. It is to be hoped that the corresponding increased profit will benefit the shareholders and not the Exchequer, seeing that such increased profit will be the result of unfairly operating the property. Doubtless, in due course, the management will announce the facts in connection with this matter.

WAGES.—The recent conference between representatives of the Workers' Union and the managers of the Camborne mines was conducted with good will on both sides, and resulted in, at any rate, a temporary settlement of the agitation for increased wages on the part of the employees of the mines in that district. After January 1, 1918, all surface hands earning less than 25s. per week are to have a 10% increase; between 25s. to 30s., a 7½% increase; and above 30s. a 5% increase. Miners hand-stoping on day-pay are to be paid 5s. to 6s. per shift according to their efficiency, while contract men are to receive at least £2 per week when working the full number of shifts. Rock-drill men on owner's account, if on development work, will receive 9s. per shift, and 7s. 9d. when stoping. Rock-drill men developing on contract are to have £11 per four weeks and £9 when stoping on contract, in each case if full time is worked. Contractors working one shift of 8 hours per day are to work 23 days per four weeks. The claim of the Union for a minimum wage for tributers, as referred to in the last issue, was abandoned as impracticable.

With the increase in value of their products, most of the Camborne mines can stand these wage advances fairly well; indeed, in some cases, they have been in operation for some time. But it is questionable whether the smaller outlying mines, whose underground forces have been so seriously depleted by the war, and who are, even at present prices, only able to just pay their way, can adopt the new standard rates of pay. The standing charges on much reduced outputs are alarmingly high, and if higher wages are to be paid, there must be a substantial increase in the outputs, which is not possible without more miners, and these can only be got from the Army. However, if the Government wants substantially increased mineral returns, a way must be found to provide the necessary labour. The War Office up to now has turned a deaf ear to all appeals, but force of circumstances may make them realize that you cannot eat the cake and have it too.

SALES AT THE TIN TICKETINGS.—The quantity of tin concentrate sold at the ticketings for the year 1917 amounted to 4,186 tons, and realized a value of £561,003, or an average price of £134 per ton. This quantity was purchased by the smelters in the following proportions:

	Tons
Cornish Tin Smelting Co., Ltd.	1,449¼
Penpoll Tin Smelting Co., Ltd.	972¾
Williams, Harvey & Co., Ltd.	819¼
Redruth Tin Smelting Co., Ltd.	630¼
London Tin Smelting Co., Ltd.	314½
	4,186

The individual mines contributed to these sales as under:

Name of Mine	Tons	Value
Dolcoath	963	£129,962
East Pool & Agar	898	121,786
South Crofty	588	81,713
Grenville United	451½	57,644
Tincroft	450	59,021
Basset	427	56,046
Levant	350	47,272
Sundry mines and tin streams	58½	7,559
	4,186	£561,003

It must be remembered that only part of the Levant production is sold through the ticketings.

TORONTO.

PORCUPINE.—The mill of the Dome Mines has been closed down owing to the shortage and inefficiency of labour and the high cost of supplies rendering it impossible to treat low-grade ore at a profit. Underground operations are also to be suspended until some time in January, when a contract will be let for sinking to the 1,500 ft. level. It has been decided to conduct all future development operations under the contract system. The directors anticipate the resumption of milling next summer on some 300,000 tons of $6 ore in the stopes, which cannot be got out until the ore overhead has been broken down. The Hollinger Consolidated has encountered a rich and extensive ore-body at the 400 ft. level of the Millerton section of the property. It is 71 ft. in width with an average gold content of about $28·60 per ton. Exploration is being pushed on an extensive scale and many surface veins have been tapped at depth. While the new milling equipment has a capacity of 2,800 tons per day, there are not sufficient men available to put it into full operation. At the Schumacher a new vein 5 ft. in width carrying ore stated to run about $10 to the ton has been struck on the 600 ft. level. It is proposed to continue the shaft to the depth of 1,000 ft. The mill is treating about 4,500 tons of ore per month. Labour is rather more plentiful, but the best men have enlisted, and the class now available are inexperienced and frequently inefficient.

KIRKLAND LAKE.—The Teck-Hughes is increasing its capitalization from $2,000,000 to $2,500,000. The new issue of 500,000 shares is offered to stockholders at $30 per share. The funds thus raised will be used to increase the milling capacity and for more extensive development. The Aladdin Cobalt has purchased the Burnside property adjoining the Tough-Oakes and will at once begin development. The Timiskaming Mining Co. has bought the Horne and Grazelle claims adjacent to the Kirkland Lake mine, and is preparing for active operations. Satisfactory results are being obtained on the Canadian Kirkland, where two shafts are being sunk, in one of which on a 16 ft. vein visible gold is in evidence at a depth of 30 ft.

RICKARD TOWNSHIP. — A large number of mining claims have been staked in this new gold camp near Lake Abitibi, some of which have been acquired by

MAP OF PART OF ONTARIO, SHOWING POSITION OF LAKE ABITIBI.

operating companies and will be speedily developed. The Mining Corporation of Canada has entered the field and is sending a plant and two diamond-drills. Interests connected with the Lake Shore mine of Kirkland Lake have acquired an option on a group of claims. A trail to the camp is being made from the Goodfish section of the Kirkland Lake area which will render it more accessible.

COBALT. — A judgment of much importance to the silver-mining companies was rendered on November 29 by Justice Middleton in an action brought by the Peterson Lake Mining Co., of Cobalt, against the Dominion Reduction Company. The question involved was the right to remove tailing deposited by the defendant company and its predecessor, the Nova Scotia Mining Co. in Peterson Lake, the bed of which is owned by the plaintiffs. For several years the tailing, then considered as valueless, was dumped in the Lake. Latterly since the adoption of the flotation process the Dominion Reduction Co. has claimed the right to remove it, and in 1915 obtained from the Peterson Lake permission to do so, provided the latter company had the direction of the point of deposit. The decision of the court is to the effect that the Dominion Reduction Co. under this agreement may remove tailing deposited since July 2, 1915, but has no claim to that dumped previous to that date. As the tailing thrown into the Lake in the earlier period was comparatively rich in silver, the value involved directly by this decision amounts to several hundred thousand dollars. It is regarded as a test case affecting the rights of several other Cobalt companies, which have deposited their tailing on adjoining properties.

PERSONAL.

H. E. ALLEN succeeded C. B. Saner as manager of the Luipaard's Vlei mine in the far west Rand in August last.

R. A. ARCHBOLD is leaving on January 17 for Nigeria.

W. N. ATKINSON, one of the British Inspectors of Mines, has been made a knight.

A. ANGUS has been appointed manager of the Tough-Oakes mine, Kirkland Lake, Ontario.

A. H. BROMLY is with the Munitions Department, in Glasgow.

E. J. CARLYLE, metallurgist to the Sissert company, is in the United States.

F. DUDLEY DOCKER has joined the Board of the British Westinghouse Electric & Manufacturing Company.

ARTHUR S. DWIGHT holds the rank of Major in the United States army and is engaged in railway construction in France.

ARTHUR FELL, Chairman of the Spassky Copper Mine, Limited, was one of the recipients of New Year's Honours, being created a knight.

H. J. GIFFORD is retiring from the position of superintendent at the Champion Reef gold mine, India.

DANIEL C. GRIFFITH & Co., of 7 and 8 Victoria Avenue, London, E.C., have admitted Walter J. J. Franks as partner.

ALLEN HASTINGS ROGERS, SYDNEY H. BALL, and LUCIUS W. MAYER have gone into partnership, with offices at 42, Broadway, New York.

H. I. KEEN, European manager of the Allis-Chalmers Manufacturing Co., of Chicago, has gone to the United States.

A. E. KITSON is returning to the Gold Coast.

CHARLES O'CONNELL has resigned as manager of the Tough-Oakes mine, Kirkland Lake, and is now manager of the Boston Hollinger mine, at Boston Creek.

H. J. ROBERTSON has been appointed assistant metallurgist at the Junction North mine, Broken Hill.

C. F. SCHALL has retired from the firm of A. Strauss & Co., which now consists of Arthur Strauss, M.P., and H. Hilty.

E. J. VALLENTINE has returned to the Federated Malay States.

R. C. WARRINER has resigned as consulting engineer to the Crown Mines and has joined the Air Service.

HENRY A. WENTWORTH has been appointed a vice-president of the American Zinc, Lead, & Smelting Co., and will take charge of the exploration department recently formed by that firm.

METAL MARKETS

COPPER. — Official prices are unchanged at £110–£110. 10s. for both cash and three months' standard. Electrolytic remains at £125–£121. The interest in the market still centres on America. Some discussion has arisen as to the prospects of an increase of the price of electrolytic there, now fixed at 23½ cents. With the increased price of mining supplies, higher wages, and the scarcity of labour a case is made out for a higher maximum; on the other hand production is increasing, the Lake output for October being reported as the largest since March, while the November refinery output has surpassed that of October although still short of the rate of a year ago. The authorities, in fixing their new prices, will be influenced by the consideration of the extent that a higher price will stimulate production. Meanwhile business has been thoroughly organized, and transfer of supplies from producer to consumer goes with satisfactory smoothness. There is a good deal less heard of sales being made in excess of the maximum. These sales seem quite against the spirit of the regulations.

Average prices of cash standard copper: December 1917, £110. 5s.; November 1917, £110. 5s.; December 1916, £145. 9s. 2d.

LEAD.—Prices in this country are still officially quoted at £30. 10s.–£29. 10s. or £29. 10s.–£28. 10s. net. This scarcely represents, however, the figure actually paid by the Government for their supplies. Much variation has taken place in the American quoted price, which has ranged between 6·37½ and 7 cents. Production is reported in excess of requirements, but vague rumours of curtailment are to hand.

Average prices of soft foreign lead: December 1917, £30; November 1917, £30; December 1916, £30.

SPELTER.—Official prices have been steady at £54–£50. This scarcely reflects the firm undercurrent in this country, and still less the improved tone in America. Sellers' ideas have considerably stiffened with the advance in the bid price. Japanese offers have been more in evidence, but the powers in this country apparently discourage shipments from that quarter, although the nation's future requirements would seem far from secure.

Average prices of good ordinary brands: December 1917, £52; November 1917, £52; December 1916, £54. 5s. 9d.

TIN.—The upward trend of prices culminated in a new high record, values for cash being carried to over £310. This regrettable position has been brought about chiefly by the strong statistical position, stocks on this side having shrunk enormously, while arrivals could not keep pace with deliveries. New Government regulations have been issued with regard to dealings, and an intimation was given that further licences for shipment to the United States from England would be suspended. The effect was quickly realized in a wild and demoralized market, and a £40 drop within a week. So much for Government control. The bottom was reached at £269. 5s. for cash and £263. 15s. three months. The downward drive had been brought about by the realization of American purchases on the fear that export would be prevented. The price in America has, however, apparently remained unaffected although the position there is rather obscure. The East too refused to follow the decline in London. It was not long therefore before a recovery took place to £279. 10s. cash and £273 three months. During the last day or two the price has bounded up again. It is reported that representations have been made to the British Authorities by the American Government against the new prohibition of export.

Average prices of cash standard tin: December 1917, £298 10s. 3d.; November 1917, £275. 2s. 10s.; December 1916, £183. 9s.

ALUMINIUM.—£225 per ton. NICKEL.—£220 per ton.

QUICKSILVER.—£22 per flask.

BISMUTH.—11s. per lb. CADMIUM.—8s. per lb.

PLATINUM.—New 290s. per oz.; scrap 260s. per oz.

MOLYBDENITE.—105s. per unit, 90% MoS_2.

WOLFRAM.—55s. per unit, 70% WO_3.

SILVER. — The market has remained firm, and the price has gradually risen during the month from 43d. to 45d. per oz.

PRICES OF CHEMICALS. January 10.

Owing to the war, buyers outside the controlled firms have a difficulty in securing supplies of many chemicals, and the prices they pay are often much higher than those quoted below.

		£	s.	d.
Alum	per ton	17	10	0
Alumina, Sulphate of	,,	17	0	0
Ammonia, Anhydrous	per lb.		1	10
,, 0·880 solution	per ton	32	10	0
,, Chloride of, grey	per cwt.	2	5	0
,, ,, ,, pure	,,	4	0	0
,, Nitrate of	per ton	65	0	0
,, Phosphate of	,,	110	0	0
,, Sulphate of	,,	15	10	0
Arsenic, White	,,	140	0	0
Barium Sulphate	,,	6	0	0
Bleaching Powder, 35% Cl.	,,	18	0	0
Borax	,,	37	0	0
Copper, Sulphate of	,,	68	0	0
Cyanide of Potassium, 98%	per lb.		1	0
,, ,, Sodium, 100%	,,			10
Hydrofluoric Acid	,,			6
Iodine	,,		14	0
Iron, Sulphate of	per ton	9	0	0
Lead, Acetate of, white	,,	135	0	0
,, Nitrate of	,,	65	0	0
,, Oxide of, Litharge	,,	42	0	0
,, White	,,	46	0	0
Magnesite, Calcined	,,	14	0	0
Magnesium Sulphate	,,	11	0	0
Phosphoric Acid	per lb.		1	3
Potassium Carbonate	per ton	190	0	0
,, Chlorate	per lb.		2	6
,, Chloride 80%	per ton	60	0	0
,, Hydrate, (Caustic) 90%	,,	400	0	0
,, Nitrate	,,	75	0	0
,, Permanganate	per lb.		15	0
,, Prussiate, Yellow	,,		3	6
,, Sulphate, 90%	per ton	65	0	0
Sodium Metal	per lb.		1	8
,, Acetate	per ton	105	0	0
,, Bicarbonate	,,	8	10	0
,, Carbonate (Soda Ash)	,,	7	0	0
,, ,, (Crystals)	,,	4	5	0
,, Hydrate, 76%	,,	26	0	0
,, Hyposulphite	,,	40	0	0
,, Nitrate, 95%	,,	27	0	0
,, Phosphate	,,	40	0	0
,, Silicate	,,	7	0	0
,, Sulphate (Salt-cake)	,,	2	12	6
,, ,, (Glauber's Salts)	,,	3	10	0
,, Sulphide	,,	35	0	0
Sulphur, Roll	,,	21	0	0
,, Flowers	,,	23	0	0
Sulphuric Acid, non-arsenical 144°T.	,,	4	5	0
,, non-arsenical 95%	,,	7	0	0
Superphosphate of Lime, 18%	,,	5	0	0

STATISTICS.

Production of Gold in the Transvaal.

	Rand	Elsewhere	Total	Value
	Oz.	Oz.	Oz.	£
Year 1912	8,753,563	370,731	9,124,299	38,757,560
Year 1913	8,430,998	363,826	8,794,824	37,358,040
Year 1914	8,033,567	344,570	8,378,139	35,588,075
Year 1915	8,772,919	320,752	9,073,671	38,627,461
Year 1916	8,971,359	324,179	9,295,538	39,484,934
January 1917	756,997	25,637	782,634	3,324,418
February	696,955	24,366	721,321	3,063,976
March	760,598	26,496	787,094	3,343,363
April	717,598	25,180	742,778	3,155,121
May	753,531	26,034	779,385	3,310,618
June	732,799	26,925	759,724	3,227,101
July	731,848	25,991	757,839	3,219,094
August	731,405	25,253	756,658	3,214,079
September	712,881	25,350	738,231	3,135,807
October	724,846	26,444	751,290	3,191,279
November	698,271	24,568	722,839	3,070 426
December	697,137	25,282	722,419	3,068,639
Year 1917	8,714,866	307,527	9,022,493	38,323,921

Natives Employed in the Transvaal Mines.

	Gold mines	Coal mines	Diamond mines	Total
January 31, 1917	188,624	11,611	5,591	205,826
February 28	191,095	11,568	6,268	208,931
March 31	190,028	11,494	6,620	208,142
April 30	185,975	11,435	6,314	203,724
May 31	180,168	11,432	5,805	197,405
June 30	175,727	11,258	5,369	192,354
July 31	171,653	11,381	5,223	188,257
August 31	170,817	11,401	5,028	187,246
September 30	171,334	11,601	4,791	187,726
October 31	170,531	11,841	4,620	186,792
November 30	169,083	11,633	4,620	185,336
December 31	172,740	11,695	4,593	189,028

Cost and Profit on the Rand.

Compiled from official statistics published by the Transvaal Chamber of Mines. The profit available for dividends is about 60% of the working profit.

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
Year 1912	25,486,361	29 2	19 3	9 11	12,678,095
Year 1913	25,628,432	27 9	17 11	9 6	12,189,105
Year 1914	25,701,954	26 6	17 1	9 0	11,553,697
Year 1915	28,314,539	26 3	17 5	8 5	11,931,062
July 1916	2,370,244	26 1	17 10	8 0	949,606
August	2,423,669	26 3	17 10	8 1	976,125
September	2,367,793	26 6	18 0	8 3	972,704
October	2,453,437	26 4	17 10	8 2	1,001,843
November	2,389,056	26 9	18 2	8 2	980,387
December	2,349,191	26 10	18 2	8 4	977,481
January 1917	2,337,066	26 10	18 8	7 11	941,520
February	2,153,691	27 3	19 2	7 10	841,259
March	2,430,590	26 7	19 0	7 4	879,351
April	2,235,833	27 2	19 2	7 8	857,710
May	2,405,855	26 4	18 7	7 5	887,527
June	2,288,426	26 11	19 2	7 7	867,639
July	2,294,668	26 11	19 0	7 7	869,577
August	2,301,892	26 9	19 0	7 6	859,517
September	2,195,884	27 5	19 4	7 9	848,096
October	2,280,461	26 10	19 5	7 2	814,211

Production of Gold in Rhodesia and West Africa.

	Rhodesia.		West Africa.	
	1916	1917	1916	1917
	£	£	£	£
January	318,586	296,113	140,579	131,665
February	313,769	289,734	137,739	104,892
March	335,368	300,183	150,987	158,727
April	339,386	297,977	135,976	123,825
May	323,783	299,271	132,976	121,104
June	333,070	302,195	127,107	114,489
July	322,365	288,731	128,574	142,017
August	338,001	294,359	125,143	130,278
September	322,035	291,367	127,138	127,168
October	325,608	289,978	132,577	126,295
November	317,135	275,829	130,101	126,915
December	306,205	...	146,409	...
Total	3,895,311	3,224,737	1,615,356	1,407,375

West Australian Gold Statistics

	Reported for Export oz.	Delivered to Mint oz.	Total oz.	Total value £
January 1917	*	83,962	*	*
February	*	81,810	*	*
March	*	76,171	*	*
April	*	82,144	*	*
May	*	78,165	*	*
June	*	82,600	*	*
July	*	81,166	*	*
August	*	80,181	*	*
September	*	81,761	*	*
October	*	73,901	*	*
November	*	80,642	*	*
December	*	78,793	*	*

* By direction of the Federal Government the export figures will not be published until further notice.

Australian Gold Returns.

	Victoria.		Queensland.		New South Wales	
	1916	1917	1916	1917	1916	1917
	£	£	£	£	£	£
January	89,900	67,627	66,700	50,150	39,000	29,000
February	76,500	65,450	79,050	63,200	30,000	26,000
March	103,600	74,794	76,920	61,200	36,000	41,000
April	60,000	75,139	83,300	62,470	63,000	21,000
May	119,500	65,623	116,230	65,450	19,000	28,400
June	86,000	64,180	72,200	73,100	18,000	24,600
July	100,600	68,937	85,400	71,820	23,000	44,000
August	66,800	...	86,000	74,800	24,000	21,000
September	115,100	...	65,450	64,180	32,000	20,000
October	81,400	...	74,800	54,400	32,000	47,000
November	94,000	...	60,300	...	31,000	29,000
December	96,600	...	73,550	...	111,000	..
Total	1,090,000	481,373	939,900	674,170	458,000	331,000

Production of Gold in India.

	1914	1915	1916	1917
	£	£	£	£
January	193,140	201,255	192,150	190,047
February	185,508	195,970	183,264	180,904
March	191,853	194,350	186,475	189,618
April	189,197	196,747	192,208	185,835
May	193,031	199,786	193,604	184,874
June	192,224	197,447	192,469	182,426
July	195,137	197,056	191,404	179,660
August	196,560	197,984	192,784	181,005
September	195,843	195,952	192,330	183,630
October	198,191	195,531	191,502	182,924
November	197,699	192,714	192,298	182,388
December	211,911	204,590	205,164	190,852
Total	2,340,294	2,369,382	2,305,652	2,214,163

Daily London Metal Prices

Copper, Lead, Zinc, Tin, in £ per long ton. Silver in pence per standard ounce.

	Copper Standard	Copper Electrolytic	Copper Best Select'd	Soft For'n Lead	Zinc	Tin Standard	Silver
Dec.	£	£	£	£ s.	£ s.	£ s. d.	d.
12	110	125	123	30 10	54 0	302 0 0	42[illegible]
13	110	125	123	30 10	54 0	301 0 0	42[illegible]
14	110	125	123	30 10	54 0	299 10 0	43[illegible]
17	110	125	123	30 10	54 0	304 0 0	43
18	110	125	123	30 10	54 0	304 10 0	43
19	110	125	123	30 10	54 0	308 10 0	43
20	110	125	123	30 10	54 0	307 10 0	43[illegible]
21	110	125	123	30 10	54 0	308 10 0	43[illegible]
27	110	125	123	30 10	54 0	302 10 0	43[illegible]
28	110	125	123	30 10	54 0	294 0 0	43[illegible]
31	110	125	123	30 10	54 0	280 10 0	43[illegible]
Jan.							
2	110	125	123	29 10	54 0	269 0 0	43[illegible]
3	110	125	123	29 10	54 0	272 0 0	43[illegible]
4	110	125	123	29 10	54 0	280 0 0	44[illegible]
7	110	125	123	29 10	54 0	281 0 0	45[illegible]
8	110	125	123	29 10	54 0	289 0 0	45[illegible]
9	110	125	123	29 10	54 0	300 0 0	45[illegible]
10	110	125	123	29 10	54 0	298 0 0	45[illegible]

With the beginning of the year lead is quoted net.

Imports of Ores and Metals into United Kingdom.

These figures now include Government imports.

* Statistics not published. Long tons.

	Year 1916	Nov. 1917	Year 1917
	Tons	Tons	Tons
Iron Ore	6,905,936	*	*
Copper Ore	34,492	*	*
,, Matte and Precipitate	43,839	3,030	24,294
,, Metal	111,412	15,667	123,511
Copper and Iron Pyrite	951,206	*	*
Tin Concentrate	33,912	*	*
,, Metal	33,646	1,350	25,624
Manganese Ore	439,509	*	*
Lead, Pig and Sheet	157,985	13,153	133,609
Zinc (spelter)	53,324	8,514	68,051
	lb.	lb.	lb.
Quicksilver	2,556,214	374,124	2,172,434

Exports of Copper from United States

1916	Long tons	1917	Long tons	1917	Long tons
July	35,048	January	25,540	July	38,127
August	34,700	February	24,937	August	45,304
September	28,572	March	51,246	September	30,493
October	32,712	April	79,001	October	39,115
November	21,433	May	45,241	—	—
December	21,438	June	39,816	—	—
Total 1916	327,277	Total	265,783	Total 1917	418,824

Outputs of Tin Mining Companies.

In Tons of Concentrate.

	Year 1916 Tons	Nov. 1917 Tons	Year 1917 to date
Bisichi (Nigeria)	473	19	247
Briseis (Tasmania)	467	26	216
Dolcoath (Cornwall)	1,076	60	769
East Pool (Cornwall)*	1,012	78	932
Gopeng (F.M.S.)	1,113	81	966
Malayan Tin (F.M.S.)	1,104	77	762
Mongu (Nigeria)	576	50	521
Naraguta (Nigeria)	523	45	458
N. N. Bauchi (Nigeria)	578	50	505
Pahang (F.M.S.)	2,591	185	2,300
Rayfield (Nigeria)	658	65	595
Renong (Siam)	894	84	934
Siamese Tin (Siam)	906	58	738
South Crofty (Cornwall)*	700	59	635
Tekka-Taiping (F.M.S.)	651	38	393
Tongkah Harbour (Siam)	1,135	93	1,096
Tronoh (F.M.S.)	1,662	81	958

* Including Wolfram.

Stocks of Tin.

Reported by A. Strauss & Co. Long tons.

	Oct. 31, 1917	Nov. 30, 1917	Dec. 31, 1917
	Tons	Tons	Tons
Straits and Australian, Spot	2,660	3,688	2,084
Ditto, Landing and in Transit	2,240	500	1,875
Other Standard, Spot and Landing	915	703	521
Straits, Afloat	*3,825	*4,500	*4,403
Australian, Afloat	—	—	—
Banca, on Warrants	—	—	—
Ditto, Afloat	*1,670	*2,600	*2,120
Billiton, Spot	—	—	—
Ditto, Afloat	*200	*300	*306
Straits, Spot in Holland and Hamburg	—	—	—
Ditto, Afloat to Continent	*1,000	*1,000	*500
Afloat for United States	*4,325	*5,727	*6,695
Stock in America	1,657	1,592	497
Total Stock	18,402	20,610	19,301

* Estimated.

Shipments and Imports of Tin

Reported by A. Strauss & Co. Long tons.

	Year 1916	Dec. 1917	Total 1917
	Tons	Tons	Tons
Shipments from:			
Straits to U.K.	27,157	*2,000	28,099
Straits to America	25,943	*2,500	24,977
Straits to Continent	8,487	*500	9,290
Australia to U.K.	2,537	—	349
U.K., Holland, and Continent to America	14,863	1,060	12,890
Imports of Bolivian Tin into Europe	15,116	1,217	19,209
Deliveries in U.K.	16,862	1,696	15,142
" ,, Holland	943	*47	1,714

* Estimated.

Nigerian Tin Production.

In long tons of concentrate of unspecified content.

Note. These figures are taken from the monthly returns made by individual companies reporting in London, and probably represent 85% of the actual outputs.

	1912	1913	1914	1915	1916	1917
	Tons	Tons	Tons	Tons	Tons	Tons
January	204	466	485	417	531	667
February	240	427	469	358	528	646
March	247	510	502	418	547	655
April	141	430	482	444	486	555
May	144	360	480	357	536	509
June	121	321	460	373	510	473
July	140	357	432	455	506	469
August	201	406	228	438	498	541
September	196	422	289	442	535	507
October	256	480	272	511	584	566
November	340	446	283	467	679	554
December	310	478	326	533	654	...
Total	2,540	5,103	4,708	5,213	6,594	6,142

Production of Tin in Federated Malay States.

Estimated at 70% of Concentrate shipped to Smelters.

Long Tons. No figures published since June.

	1913	1914	1915	1916	1917
	Tons	Tons	Tons	Tons	Tons
January	4,121	4,983	4,395	4,316	3,558
February	3,823	3,555	3,780	3,372	2,755
March	3,562	3,839	3,653	3,696	3,286
April	4,066	4,087	3,619	3,177	3,251
May	4,319	4,135	3,823	3,729	3,413
June	3,993	4,303	4,048	3,435	3,489
July	4,245	4,582	3,544	3,517	...
August	4,620	3,591	4,046	3,732	...
September	4,379	3,623	3,932	3,636	...
October	4,409	3,908	3,797	3,681	...
November	3,976	4,085	4,059	3,635	...
December	4,614	4,351	4,071	3,945	...
	50,127	49,042	46,767	43,871	19,752

Sale of Tin Concentrate at Redruth Ticketings.

	Long tons	Value	Average
January 2, 1917	176	£17,677	£100 8 10
January 15	160¾	£16,681	£103 15 5
January 29	152	£16,095	£105 17 10
February 12	182¼	£20,649	£113 6 1
February 26	176¾	£19,700	£111 9 3
March 12	179	£20,468	£114 7 0
March 26	161¾	£19,875	£122 17 8
April 10	179	£22,024	£123 2 0
April 23	169	£21,429	£126 16 0
May 7	167	£22,248	£133 4 6
May 21	168¼	£23,772	£141 5 9
June 4	168	£22,474	£133 15 6
June 18	158½	£21,915	£138 5 4
July 2	159½	£21,661	£135 16 1
July 16	144¼	£18,896	£130 19 11
July 30	168	£23,225	£138 5 0
August 13	160¼	£21,757	£135 15 4
August 27	156½	£21,429	£136 18 6
September 10	160¼	£21,784	£135 18 9
September 24	153	£21,448	£140 3 9
October 8	160½	£22,160	£138 11 6
October 22	153	£21,712	£141 18 2
November 6	144¼	£21,063	£146 0 5
November 19	156	£24,737	£158 11 6
December 3	148	£24,609	£165 5 6
December 17	148½	£25,620	£172 10 7
December 31	151¾	£23,450	£154 10 8
Total, 1917	4,186	£561,003	£134 0 0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS:	Jan. 5, 1917 £ s. d.	Jan. 5, 1918 £ s. d.
RAND:		
Bantjes	11 6	3 0
Brakpan	4 17 6	5 11 3
Central Mining (£8)	6 18 9	6 5 0
Cinderella	5 0	3 9
City & Suburban (£4)	1 17 6	1 3 9
City Deep	4 5 0	3 8 0
Consolidated Gold Fields	1 10 0	1 10 6
Consolidated Langlaagte	1 8 0	1 1 0
Consolidated Main Reef	18 0	15 6
Consolidated Mines Selection (10s.)	1 1 9	1 8 9
Crown Mines (10s.)	3 0 0	2 1 3
Daggafontein	14 0	1 9 6
D. Roodepoort Deep	11 3	10 6
East Rand Proprietary	12 3	5 6
Ferreira Deep	1 2 6	13 9
Geduld	2 4 0	1 18 6
Geldenhuis Deep	1 3 9	17 6
Gov't Gold Mining Areas	2 13 0	3 16 3
Heriot	2 12 6	1 16 3
Jupiter	2 0	5 0
Kleinfontein	1 5 0	1 1 9
Knight Central	10 0	3 3
Knight's Deep	1 6 3	10 0
Langlaagte Estate	18 0	15 3
Main Reef West	4 6	2 9
Meyer & Charlton	5 11 3	5 12 6
Modderfontein (£4)	18 18 9	23 5 0
Modderfontein B	7 12 6	8 12 6
Modder Deep	7 6 3	7 12 6
Nourse	1 1 6	1 0 0
Rand Mines (5s.)	3 13 9	3 1 3
Rand Selection Corporation	3 11 3	4 12 6
Randfontein Central	13 3	11 3
Robinson (£5)	18 0	18 9
Robinson Deep A (1s.)	1 15 0	1 3 9
Rose Deep	1 1 6	1 2 6
Simmer & Jack	7 0	5 6
Simmer Deep	4 6	2 9
Springs	3 1 6	3 13 0
Sub-Nigel	1 7 6	1 9 6
Van Ryn	2 0 0	1 5 6
Van Ryn Deep	3 10 0	3 13 9
Village Deep	1 9 6	1 2 0
Village Main Reef	16 3	15 0
Witwatersrand (Knight's)	2 13 9	1 17 0
Witwatersrand Deep	1 1 6	7 0
Wolhuter	9 6	7 6
OTHER TRANSVAAL GOLD MINES:		
Glynn's Lydenburg	16 3	1 0 0
Sheba (5s.)	1 9	1 3
Transvaal Gold Mining Estates	1 0 6	18 3
DIAMONDS IN SOUTH AFRICA:		
De Beers Deferred (£2 10s.)	13 2 6	13 15 0
Jagersfontein	4 6 3	4 7 6
Premier Deferred (2s. 6d.)	7 5 0	7 0 0
RHODESIA:		
Cam & Motor	9 6	10 9
Chartered British South Africa	12 0	15 0
Eldorado	9 3	7 6
Falcon	15 9	19 6
Gaika	8 3	6 6
Giant	6 0	9 3
Globe & Phœnix (5s.)	1 17 0	1 11 3
Lonely Reef	1 4 6	1 13 6
Rezende	8 9	4 17 6
Shamva	1 4 6	1 12 6
Wanderer (3s.)	4 9	2 0
Willoughby's (10s.)	4 6	5 3
WEST AFRICA:		
Abbontiakoon (10s.)	5 0	4 0
Abosso	8 6	7 6
Ashanti (4s.)	18 9	1 1 0
Prestea Block A	7 0	4 3
Taquah	17 0	16 6
WEST AUSTRALIA:		
Associated Gold Mines	4 0	2 0
Associated Northern Blocks	3 0	2 6
Bullfinch	2 6	2 0
Golden Horse-Shoe (£5)	1 14 6	2 5 0
Great Boulder Proprietary (2s.)	11 3	13 0
Great Boulder Perseverance	1 0	—
Great Fingall (10s).	1 0	1 3
Ivanhoe (£5)	2 2 6	2 4 6
Kalgurli	10 6	11 0
Sons of Gwalia	13 9	12 6

GOLD, SILVER, *cont.*	Jan. 5, 1917 £ s. d.	Jan. 5, 1918 £ s. d.
OTHERS IN AUSTRALASIA:		
Mount Boppy, New South Wales	7 6	6 0
Talisman, New Zealand	7 6	15 0
Waihi, New Zealand	1 14 6	1 17 3
Waihi Grand Junction, New Z'lnd	16 6	17 0
AMERICA:		
Alaska Treadwell (£5), Alaska	2 12 6	—
Buena Tierra, Mexico	12 6	10 0
Camp Bird, Colorado	6 0	7 6
Casey Cobalt, Ontario	4 9	6 3
El Oro, Mexico	7 6	7 9
Esperanza, Mexico	8 9	7 6
Frontino & Bolivia, Colombia	13 6	12 6
Le Roi No. 2 (£5), British Columbia	9 6	6 3
Mexico Mines of El Oro, Mexico	3 12 6	5 12 6
Oroville Dredging, California	16 0	18 3
Plymouth Consolidated, California	1 0 0	1 2 6
St. John del Rey, Brazil	16 9	17 9
Santa Gertrudis, Mexico	8 9	14 0
Tomboy, Colorado	1 0 9	1 1 0
RUSSIA:		
Lena Goldfields	1 15 0	1 10 0
Orsk Priority	1 0 0	12 6
INDIA:		
Champion Reef (2s. 6d.)	5 9	5 6
Mysore (10s.)	3 5 0	3 0 0
Nundydroog (10s.)	1 5 6	1 4 6
Ooregum (10s.)	19 9	18 6

COPPER:

Arizona Copper (5s.), Arizona	2 6 3	2 7 0
Cape Copper (£2), Cape Province	4 0 0	2 17 6
Chillagoe (10s.), Queensland	3	9
Cordoba (5s.), Spain	4 0	3 0
Great Cobar (£5), N.S.W.	2 0	1 6
Hampden Cloncurry, Queensland	1 14 6	1 11 6
Kyshtim, Russia	2 5 0	1 10 0
Messina (5s.), Transvaal	10 0	8 6
Mount Elliott (£5), Queensland	5 15 0	3 10 0
Mount Lyell, Tasmania	1 5 0	1 5 9
Mount Morgan, Queensland	1 12 6	1 13 6
Rio Tinto (£5), Spain	62 15 0	64 0 0
Sissert, Russia	1 5 6	1 0 0
Spassky, Russia	1 17 6	1 5 0
Tanalyk, Russia	2 8 9	1 10 0
Tanganyika, Congo and Rhodesia	2 8 9	3 10 0
Tharsis (£2), Spain	5 0 0	5 10 0

LEAD-ZINC:

BROKEN HILL:		
Amalgamated Zinc	1 11 6	1 11 9
British Broken Hill	1 5 6	1 15 6
Broken Hill Proprietary (8s.)	2 11 6	2 12 9
Broken Hill Block 10 (£10)	1 0 0	1 4 0
Broken Hill North	2 4 0	2 14 0
Broken Hill South	8 8 9	9 7 6
Sulphide Corporation (15s.)	1 8 9	1 8 3
Zinc Corporation (10s.)	14 9	19 3
ASIA:		
Burma Corporation	3 18 0	4 0 6
Irtysh Corporation	2 5 6	1 10 6
Russian Mining	17 6	12 6
Russo-Asiatic	5 11 3	3 3 9

TIN:

Aramayo Francke, Bolivia	1 7 6	1 14 6
Bisichi, Nigeria	10 6	14 6
Briseis, Tasmania	4 6	5 0
Dolcoath, Cornwall	10 0	11 9
*East Pool, Cornwall	1 11 3	16 9
Ex-Lands Nigeria (2s.), Nigeria	1 6	2 0
Geevor (10s.) Cornwall	8 9	17 9
Gopeng, Malay	1 8 9	1 13 9
Ipoh Dredging, Malay	16 3	16 0
Malayan Tin Dredging, Malay	1 17 6	2 3 9
Mongu (10s.), Nigeria	9 0	14 6
Naraguta, Nigeria	14 6	17 0
N. N. Bauchi Pref. (10s.), Nigeria	7 0	11 9
Pahang Consolidated (5s.), Malay.	10 0	11 6
Rayfield, Nigeria	6 6	12 3
Renong Dredging, Siam	2 2 6	2 10 0
Ropp (4s.), Nigeria	16 3	17 0
Siamese Tin, Siam	2 10 0	2 17 6
South Crofty (5s.), Cornwall	15 6	1 1 6
Tekka, Malay	3 2 6	3 12 6
Tekka-Taiping, Malay	3 1 3	3 15 0
Tronoh, Malay	1 8 0	1 10 0

* £1 shares split into 4 of 5s. each in August 1917.

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also reviews of new books, and abstracts of the yearly reports of mining companies.

ELECTRIC STEEL FURNACE ON THE RAND.

Owing to the war, it was found advisable to procure as many supplies for the mines on the Rand from local sources as possible. For instance many machines or parts of machines could be made from steel remelted from scrap. One of the notorious wastages in the past has been in connection with worn shoes and dies of stamp mills, for these are removed at a period when about 15% of the steel remains, and they have hitherto been thrown away or made into paving blocks. A committee investigated the subject and inquired into the various types of furnace available for remelting purposes. Finally an electric furnace of the induction type, well known by the name of Kjellin, the inventor, was adopted. In a paper read before the Chemical, Metallurgical, & Mining Society of South Africa on September 29, Professor G. Hardy Stanley described the furnace and its performance. The subject was also treated at the same meeting by Professor W. Buchanan from the point of view of the electrical engineer. We give herewith an outline of Professor Stanley's paper, together with some of the illustrations.

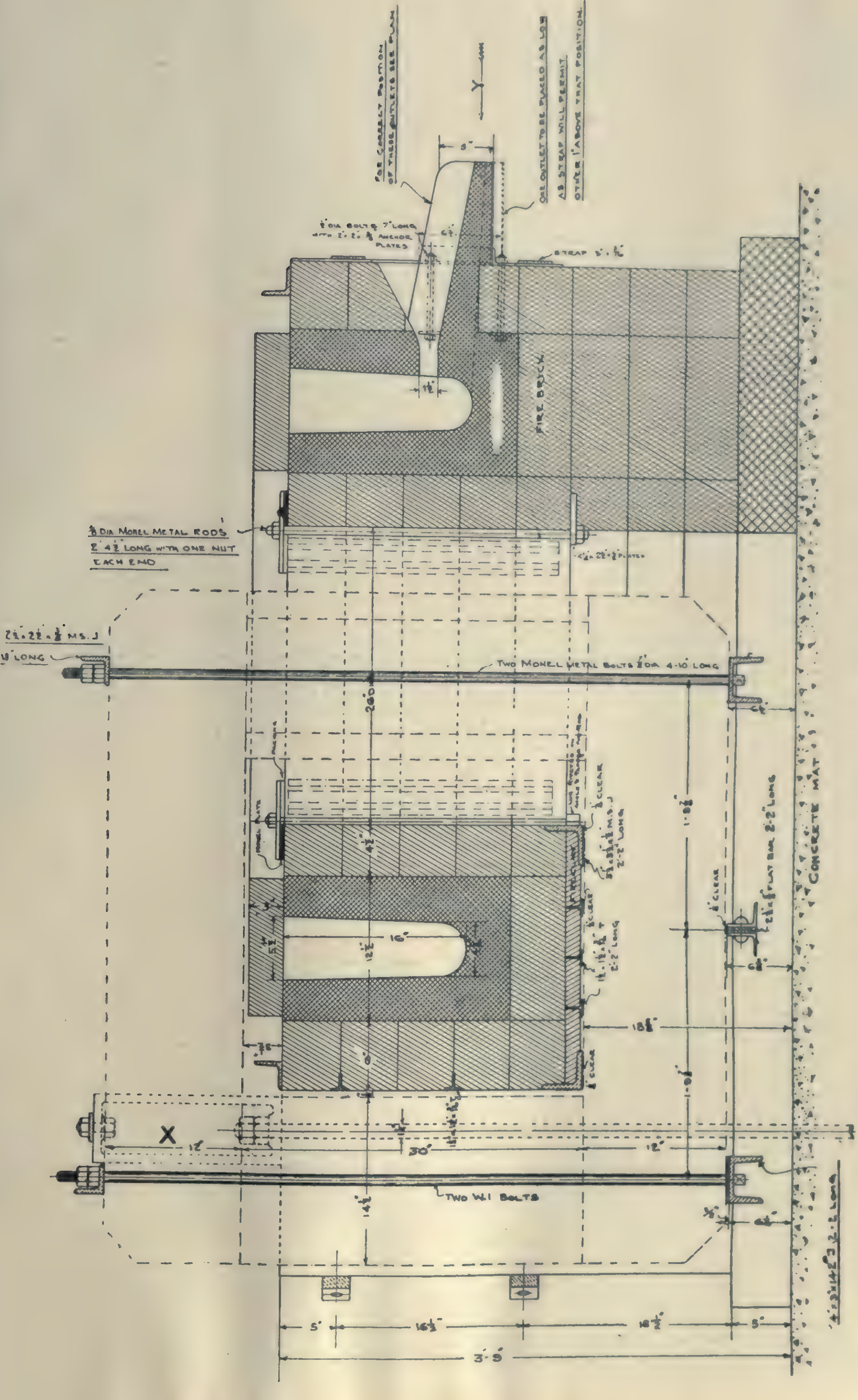
A site and building were secured on the Robinson mine and work was commenced in the middle of May. Current was switched on to the furnace on September 3. The electrical arrangements were under the charge of Professor Buchanan. The electrical supply is obtained from the Victoria Falls & Transvaal Power Co., Ltd., at 2,000 volts, 3 phase, 50 cycles, by means of an underground cable from the nearest transformer house, about 300 yards distant. To supply current to the furnace a rotary transformer set was installed, consisting of a motor coupled to two generators and running at 250 r.p.m., giving a single phase current up to 600 amperes at the low frequency required, about 12 cycles. The power consumption at the furnace is about 800 to 900 kw.h. per ton of steel melted. The construction of the furnace is shown in the illustration. The cores and yokes are built up of old transformer iron, and the primary winding, consisting of copper cable insulated with asbestos tape is placed in a 3 in. coil space between the core and inner walls of the furnace. Between the inner wall and the coil itself, a cylindrical shield of asbestos sheet was placed with the idea of protecting the coil in case of the steel breaking through the wall. Instead of elaborate water-cooling arrangements, air circulation alone is depended on for cooling the coil, a ventilating cowl of asbestos millboard being placed over the centre and connected to a chimney passing through the roof. This arrangement effects a considerable simplification of design, and does not seem to be attended with serious drawbacks. The body of the furnace is built up of special radial and rebated segments made at Vereeniging, tied over all with steel hoops, terminating in screwed ends passing through yokes, so that tightening or loosening can be effected. Any further iron or steel work being very undesirable from the electro-magnetic point of view, the plates between these and the brickwork were made of monel metal. This alloy is used, replacing iron or steel, wherever desirable and possible in this furnace. To keep the power factor as high as possible, the interior wall is made 8 in. thick, while the outer brickwork has a thickness of 9 in., in each case laid in fireclay. The cover bricks are of radial shape, 2 in. thick, and to prevent breaking or cracking, are clamped by means of monel metal rods flattened and bent over at the ends, and with screws put through so that they may be tightened up. A strip between them serves for lifting when required.

In the annular trough formed between the inner and outer walls the working lining of the hearth is placed. One of the initial difficulties was the selection of a suitable material for this lining. Knowing that reasonably pure magnesite occurred in the country, it was originally intended to construct the lining of calcined magnesite, but owing to the difficulty of satisfactorily calcining this material the first lining was made by ramming ganister, prepared by grinding together pure quartz with a small amount of fireclay, round a sectional wooden template, moved from place to place round the furnace till the lining was complete.

After removing the template, which left an annular trough 16 in. deep by 5½ in. wide, the lining was allowed to dry naturally over night, and was then warmed up by a fire bucket inside the central core space, and finally by burning wood in the hearth. Then, in order to further heat and start the furnace, coils of discarded wire haulage rope were placed in the hearth, the iron yoke fitted into place, and current switched on. As the temperature rose, the expansion of the ganister caused it to crack in several places and strip away from the brick of the inner wall. Experiments had then to be made with the object of finding a better lining. Eventually a lining of chromite was built inside the brickwork, faced internally with about 2 in. of tar-magnesite mixture. The heating was started as before with wire rope and molten cast iron, and this time with success. Another difficulty was subsequently remedied by modifying the shape of the template to give a hearth 7½ in. by 13 in., and so facilitate the feeding of awkwardly shaped pieces of scrap, though doubtless this was done at the cost of a certain loss of electrical efficiency. It may be mentioned that the slag adhering to the walls reduces the free space for feeding, so that the original width of 5 in. sometimes made feeding extremely difficult.

The position as regards magnesite came under investigation. It was found that nearly pure magnesite was obtainable from Kaapmuiden and a consignment of this was obtained and calcined at Vereeniging. Commencing with the employment of a magnesite lining, process was rapid, and early this year operations became nearly normal. The frequency of tapping has increased until for some time between 1,900 and 2,000 lb. of castings have been regularly obtained every eight hours, and now the period is being reduced to six hours.

Apart from the material of the lining, the chief difficulty in the early stages was oxidation of the metal and consequent loss of carbon and manganese content, which besides softening it, made it much less fusible. This was due to the rust on the scrap, to scale formed



VERTICAL SECTION OF INDUCTION FURNACE FOR MELTING STEEL SCRAP AS USED ON THE RAND during preheating, and partly also to admission of air to the furnace by defective covers. When, in the early stages, a heat lasted sometimes 24 hours or more, it is not surprising that on occasion all the carbon was lost, and dead soft iron was produced. This has been remedied by more rapid working, and by keeping a little charcoal on the top of the metal in the furnace.

The chief furnace trouble at present is the formation of a crust of solid metal more or less completely covering the surface of the molten metal. It is not serious if noticed and dealt with in time, but if allowed to increase by building up and feeding more metal, it entails much labour and risk of damage to the walls in detaching it. It does not seem of any assistance to try to make a slag, which indeed is difficult to keep fluid, but sometimes to clean the metal a little fluorspar has been added. Another difficulty, in a recent lining, arose from trying to incline it toward the tap hole. This reduced the cross section of steel too seriously at the other side, and caused several breakages of circuit, probably due to the pinch effect, after tapping; so that the tap hole had to be raised. However, having the hearth level leaves a ring of metal every time the furnace has to be completely tapped out for relining.

In normal operation, lining and working proceed as follows: The old lining having been stripped out immediately it had cooled sufficiently, and after removing the top transformer yoke, the bottom is rammed into place with hot rammers, little by little, and then the template or former is supported in position. This is constructed in such form that when the ramming is completed, by taking out the top pieces, the sides can collapse to some extent, thus loosening and facilitating withdrawal. Lately the bottom has been made rather more V shaped, so as to keep a continuous ring with less weight of metal. The walls are then rammed in the same manner, and when complete, about 12 hours from the last tapping, the template is withdrawn, the walls completed with a course of flat radial brick, the coil of rope inserted and the yoke replaced, this occupying about three hours more. Current is then switched on, and the furnace is ready for more foundry metal within 30 hours of the last cast. Three ladles, about 500 lb. in all, are then carried across from the foundry and poured in. Generally this solidifies, but in two or three hours is molten again and feeding of scrap commences. The scrap has been heated to redness in the furnace attached to the drying stove, and is transferred by means of tongs to the electric furnace, feeding in several places through spaces left by removing a cover block. This is kept up for two or three hours more, about 2,000 lb. of scrap having been charged, after which the metal is left at rest to become hotter and ready for casting, no metal being ordinarily fed within one hour of tapping. At this stage the required amount of pig iron and manganese steel is added. Toward the end, most of the slag is skimmed off on the end of flat iron bars, and shortly afterward the top tap-hole is opened in the usual manner, by drilling out its centre, which has been plugged by a friable mixture of magnesite, coal dust, and clay, the hole itself being lined with the same mixture as the furnace. When the flow of metal has practically ceased, it is stopped by placing two or three suitable flat pieces of scrap against the tap-hole inside the furnace. Any metal in the tap-hole is removed while hot. This removal is important, or a break-away may be caused subsequently. Thereafter charging goes on as before, but with scrap only, except for the additions at the end. The first two or three heats are cast into dies, on account of the high carbon, sulphur, and phosphorus content due to the cast iron, which would lead to breakage of shanks if cast into shoes. Thereafter three shoes and five or six dies, or latterly even eight shoes, are made per cast. Cracks and holes appear in due course in the lining, but so far it has not been found possible to patch them successfully.

A tilting furnace would obviously have prevented much trouble with regard to the tap-hole and tapping, and could doubtless have been made, but in view of the necessity of keeping initial outlay as small as possible the fixed form was decided upon. This usually necessitates the intervention of a ladle between the furnace and moulds, the metal being tapped into the ladle and poured thence into the moulds. Originally, therefore, a ladle and suitable handling gear was installed, the intention being to pour over the lip. However, owing largely perhaps to slow and inexperienced handling in the early stages a very large proportion of the steel melted partly solidified in the ladle, forming skulls which constituted so much waste, as it was impossible with the available appliances even to break them up for remelting. In addition, the frequent relining required entailed much expense and delay. Hand ladles or shanks of smaller size were then substituted for a time, three being used in rotation at each cast. This arrangement reduced the loss to some extent, though it was still large. But there was still much lining to be done and, moreover, it was very awkward to operate in the somewhat confined space. Therefore, after some other trials the present method was arrived at. The tapping spout is somewhat lengthened, and has attached to its end a box of sheet steel provided with a bottom outlet through a fireclay nozzle, and forming a kind of forehearth. The spout and forehearth are lined as usual and, of course, patched and faced after every cast. The outlet can be closed by means of a fireclay plug, as usual in bottom teeming steel ladles, this plug being carried on a rod actuated by a lever in front, worked by hand. Directly underneath this, and at right angles to the spout, is a line of rails on which a series of flat bogies carries the moulds, so that they can be moved in turn underneath the nozzle. When the furnace is tapped, the metal runs into the forehearth, and from thence, after a few seconds, to the first mould, by opening the outlet. When the mould is full, the plug is lowered to shut off the stream, and the next mould is pulled into position, and so on. Two moulds are mounted on each bogie, and all of them are coupled together in a train pulled by a wire rope by means of a hand winch at the front end. This has considerably raised the daily output, and on several days over 3 tons of castings have been produced.

It was soon ascertained that it was much easier and simpler to cast into the iron moulds with sand tops, and the operation requires less skill; consequently nearly all the production has been made in this manner. But, while overcoming certain troubles, the use of iron moulds introduces others; for instance, when, in the case of shoes, the bottom of the mould, forming the shank of the shoe, is worn and rough, it tends to grip the solidified metal and prevent it shrinking normally, thus leading sometimes to cracking at the butt. In use, this crack rapidly results in breakage. This may be overcome in future by moulding the shanks only in sand.

Working costs are somewhat high on account of the small scale of the operations, labour in particular being a very big item; in fact the same number of hands could probably turn out two or three times the present output with a larger furnace. Running, as it does, continually day and night, Sundays included, three eight-hour shifts are worked, and each of these requires an electrician in charge of the electrical plant and a furnaceman or moulder in charge of the furnace; for this latter it has been difficult to secure suitable white workmen, and coloured labour is employed therefore on some shifts under supervision of the electrician; consequently the number of white furnacemen on the pay roll varies between one and three. The actual furnace charging is done by "Cape boys," of whom 5 or 6 are employed in all, and about 15 natives are used in breaking up scrap and miscellaneous labour. All are under the charge of a works manager, so that the wages bill and supervision fees amount to about £400 per month. Electric power is the next big item, and amounts to close on £200 per month, and the cost of scrap at £1 per ton is third.

The largest output so far was obtained in July, when 73 tons of castings were produced at a works cost of less than £14 per ton. In August nearly 69 tons was made, so it is quite safe to assume an average output of 60 tons per month. For this the costs would be approximately as follows:—

Scrap, 70 tons, @ £1	£70	0	0
Pig iron, 1½ tons, @ £20	30	0	0
Aluminium, 30 lb., @ 2s.	3	0	0
Magnesite (calcined), 2 tons, @ £18	36	0	0
Miscellaneous stores	15	0	0
Repairs and renewals	15	0	0
Tools, etc.	5	0	0
Electric power	200	0	0
Cartage	30	0	0
Miscellaneous sundries	20	0	0
Salaries, wages and supervision fees	400	0	0
	£824	0	0

or nearly £14 per ton.

OIL PROSPECTS IN BARBADOS.

A paper was read by E. H. Cunningham Craig on December 18, before the Institution of Petroleum Technologists, dealing with the geological history of Barbados and the chances of finding oil in commercial quantities in that island. Barbados is not far to the north of Trinidad, and as the geology of the two islands is similar in many respects, the success of the Trinidad operations has turned attention to other components of the Caribbean basin.

There are three distinct geological formations in Barbados, in ascending order, (1) the Scotland Beds, a littoral, estuarine, and deltaïc group of strata, probably of early Tertiary age according to the latest evidence, (2) the Oceanic Beds, and (3) the Coral Limestone. The Oceanic Beds, probably of Miocene and later age, overlie with an unconformability, which is not always very obvious or pronounced, the Scotland Beds, while the Coral Limestone of Recent age overlies both with a distinct and striking unconformability. The island lies upon the outer rim of the great Caribbean basin. This outer rim, obviously a recent earth-fold of considerable importance, curves round from an off-shoot of the Andean chain in Colombia and Venezuela through Trinidad, Tobago, and Barbados to Barbuda, and so through Anguilla and the Virgin Islands to Porto Rico, San Domingo, and Cuba. The island is built upon and round a core of intensely folded beds of the Scotland series, the strata being arenaceous below and more argillaceous in the higher horizons. The major folds, where they are best seen, strike E. 20° N. and W. 20° S. The general south-westerly pitch of the folding—especially toward the centre of the island—indicates how large a part of the central core has been removed by denudation. Simultaneous with the earliest folding, or immediately following it, the area began to sink in the trough of a great earth-wave. At the commencement of this trough-subsidence, denudation of the folded Scotland Beds took place, but as the movement continued, the zone of denudation was passed through, and formation of Oceanic deposits ensued. The next period of which there is record, is again one of extensive movement. The trough of the earth-wave had passed, and the outer rim of the basin began to rise on the crest. A distinct and considerable folding movement accompanied this gradual elevation; indeed, the lateral thrust that caused the folding had probably the effect of bringing the strata that now form Barbados from a position in the trough gradually up the rising slope of the crest. The effect of this movement is seen in the folding of the Oceanic Beds into well-defined and fairly steep but not very extensive anticlines and synclines. The direction of movement, however, was not the same as in the earlier movement. The new flexures are orientated N.E. and S.W., with a tendency in the latter stages to diverge still more toward a northerly and southerly direction. The relation of the locality to the great concentric rings of the earth-waves makes it inevitable that such a gradual change in direction of thrust must have taken place. The effect of this oblique movement upon the earlier folds of the Scotland Beds was that the major folds were compressed more acutely, the less sharply folded areas were bent into north-east and south-west flexures, and a certain amount of minor faulting, chiefly strike-faults of the later stages of the flexuring, enabled the older strata to adjust themselves to the altering conditions. Meanwhile the outer rim of the Caribbean basin was rising slowly and steadily, and the land-surfaces to eastward and southward had disappeared in another trough. In due time Barbados may be said to have been born, first as a coral reef, the folded mass of strata having been brought upward to the depth at which coral can grow. Much denudation of the soft Oceanic deposits certainly took place during this elevation, and the first fringing reef of coral dipped gently seaward from a planed-down surface of both Oceanic and Scotland Beds. Thereafter, Barbados rose from the waves in successive stages, each marked by its horizontal coral terrace, till it has reached in Mount Hillaby a height of 1,105 ft. above sea-level. It is possible that the movement of elevation has not yet ceased.

Everywhere where the Scotland Beds are exposed there are traces of petroleum. In many cases there are good seepages of heavy oil; there are innumerable outcrops of oil-sand, more or less dried up, in two or three localities the presence of manjak veins gives evidence of petroleum at greater depths; and there is one natural gas well, the long-known "Boiling Spring." But the Scotland Beds present no broad, well-defined anticlines for testing; the folding is very sharp and irregular, and the dips steep, and, though the upper beds are largely argillaceous, they have frequently been denuded and so cannot have served to seal up stores of petroleum, except in a very minute and local manner. Practically every attempt to win oil has been made in the vicinity of outcrops of oil, and where the petroliferous beds are fully exposed and dipping very steeply. All such attempts have attained a measure of success, an asphaltic oil, sometimes heavy and sometimes light, having been obtained in quantity sufficient to encourage the prospectors; but the yields soon fell off to an unremunerative total, and, though one or two wells are still being pumped occasionally, the production of oil is negligible. The problem is to find localities where the Scotland Beds, however sharply and irregularly folded, have been preserved from excessive denudation and inspissation, and where there is some hope of a sufficient concentration of petroleum contents to give production of commercial importance.

It is evident that later or post-Oceanic flexures must be of much greater importance in this connection than the earlier folding. To begin with, it is broader and more gentle. Again, the Oceanic Beds, if not entirely denuded, must have some effect in sealing up petroleum in the Scotland Beds beneath them. Also the anticlinal flexures of the Oceanic series must have affected the underlying strata. It became necessary, therefore, to trace out the broadest and best defined of the post-Oceanic flexures, and by a study of their orientation to follow them beneath the capping of coral that wipes out all evidence of the older rocks. This can only be done very imperfectly at present, since there are no deep drilled wells to guide the prospector; but by the help of water-wells and isolated outcrops, and keeping constantly in mind what has been learnt of the earth-movements and their variations in direction and intensity, it has been possible to indicate, over a considerable portion of the island, the lines upon which development work should be conducted. It may be stated at once that there are several small areas where the prospects of obtaining petroleum in fair quantity are distinctly bright. The order in which prospecting wells should be drilled has been given, the depths to which such wells should be drilled have been suggested, the special difficulties in such cases have been indicated, and short of actually locating the wells, all advice that it seemed possible to give in the special circumstances has been given. It is not suggested that there can ever be a great and prolific oilfield in Barbados; but it is safe to say that there is every probability of moderate productions being obtained in the most favourable localities.

SUMATRAN GOLD MINING IN THE EARLY DAYS.

The *Phœnix*, the magazine of the Imperial College of Science and Technology, contains in its December issue an interesting account of prospecting operations for gold in ancient times in Sumatra. A note at the head of the article states that it is written by a member of the teaching staff of the Royal School of Mines, and it is easy to guess that Mr. Arthur Yates is the individual indicated. The author remarks prefatorily that the legend forming the basis of the article, relating to the original inhabitants of the district Redjang-Lebong in the West Coast of Sumatra and their gold-mining, was taken down as told in Malay, by Soeta Maroean of Mokko-Mokko, and then translated into English, and that it is interesting to note that nothing of value has been found in the course of some twenty years prospecting and mining in the district but what was known to the ancients. The mines working in the district at the present time are: the Redjang-Lebong, Ketahoen, Simau, Tambang-Sawah, and Sempang. The other mines mentioned in the legend have not proved rich enough for exploitation. The principal mine, Redjang-Lebong, lies 72 kilometres N.N.W. of the seaport of Benkoelen on the south-west coast of Sumatra.

In the year 1241 A.D., so the story is told, there was in the district Pagar Roejoeng a Radjah named Sultan Daulat Mahkoeta Alamsjah, a descendant of Alexander the Great of Macedonia, having authority over several dependent states in Sumatra. His was a very powerful kingdom, its fame extending to other countries. There came a day when this Sultan commanded a prince named Imbang Djaja to visit his dependent states, Koerintji, Djambi, and others, and requested him to look out for mountains rich in gold. Prince Imbang Djaja set forth on his expedition, taking with him four friends of his, chiefs, whose names were Datoek Radjah Sabo, Datoek Radjah Bintang (bintang = star), Datoek Bergoembak Paudjang (paudjang = long), and Datoek Radjah Siang (siang = early). Besides these he took a black dog, an ajam broego (jungle fowl) and a bird called boerang poejoeh (boerang = bird, a sort of quail), because these three animals would help by pointing out where gold was likely to be found. They went first to Koerintji, and Prince Imbang Djaja examined the district and defined its boundaries, at the same time searching the mountains for gold mines. Arriving at the doesoen (village) Hiang, he found there a mountain—Mandai Oerai (shower bath)—rich in gold. Here he stayed for some time, directing the Koerintjis to open up mines, and thus finding quite a number of other mountains where gold existed.

Having examined Koerintji, the Prince set out for Djambi. He gave orders that the Radjah of Djambi should make the country suitable for settlement, and search for and open up mines. He stayed here for some time, finding several hills and rivers showing good "prospects." Thence the Prince journeyed westerly, and following a range of mountains he reached the Ajer Seblat (ajer = stream) and followed it down to its junction with the Ajer Poetih (white stream). Here the ajam broego crowed, so the expedition halted and commenced prospecting for gold. After a brief stay, however, the whole party went on to Ajer Segalengai, where the cock proceeded to crow several times. Thereupon Prince Imbang Djaja halted again and began prospecting both on the hills and in the river. As he secured a lot of gold there, he built a village on the bank of the Segalengai, and gave Datoek Radjah Sabo orders to fetch men from Koerintji, who were to live in the Segalengai village and work in the mine under his direction. It is said that every day while the Prince stayed at Segalengai, the white cock was seen to crow at sight of the Lebong mountains. On that account the Prince, leaving behind Datoek Radjah Sabo, again set out in the direction of the range of mountains. On arrival at the mouth of the Ajer Poetih near the foot of this range, the white cock flew up on a rock and crowed and cackled (berketek) seven times, and to this day there is at that spot a stone which men call "batoe berketek" (batoe = stone). Here at the mouth of the Ajer Poethih a halt was made, and after some prospecting gold was found, so the Prince built a village on top of the ridge and mined there for gold. A long stop was made and sawahs (irrigated rice fields) sprang up round about the mine, so that to this day the place is called Tambang Sawah (tambang = mine).

Now every day Prince Imbang Djaja noticed that the ajam broego and the boeroeng poejoeh gave voice as it were toward Goenoeng Lebong (geonoeng = mountain), so, bidding Datoek Bergoembak Pandjang stay as headmen at the mine, he himself set out with his men in the direction of the Ajer Ketahoen, intending to prospect Goenoeng Lebong. Reaching the Ketahoen he crossed it, and went on to a small stream, where the dog began to bark, and then entered the water, and followed by the Prince and his men, went upstream till they came across and bit the tail of a large animal like an iguana, of a shining red colour. Then said the Prince to his friends, "This surely is the Biang Mas" (mother of gold). "Let us follow it to its hiding place." They immediately set off in pursuit of the animal, which closely followed the stream almost to the foot of Goenoeng Lebong, and then disappeared into its lair, a hole (lebong) in the ground. "Here, indeed," said Imbang Djaja, "is the hiding place of the Biang Mas. Let us stay and make a village on this mountain." So a halt was made, a village built, and a mine commenced and opened up. Gold was found in great quantities both in the soil and in the rock. (They had found the famous Redjang-Lebong Mine). This they sold to the Portuguese and English who had long been settled on the coast. Prince Imbang Djaja now returned to Pagar Roejoeng and told Sultan Daulat Mahkoeta Alamsjah all about his discoveries, mentioning that Datoek Radjah Bintang and Datoek Radjah Siang had stayed behind as headmen in Doesoen Lebong. As soon as the Sultan had heard of the richness of Lebong Mountain he directed Prince Imbang Djaja to return and take with him a large number of men to make villages and establish communities in Lebong district. No time was lost on the return journey and as soon as the Prince reached Lebong he set about building villages and opening up mines, and continued to live there for some time.

In the course of time there arrived from Indrapoera a young prince, Radjah Ibeng. The newcomer had not been in the district very long before he ran away with a Lebong maiden to Tambang Sawah, and then, fearing he might be killed by Lebong men, he carried her off to a mountain at Soelit (secret), where he went into hiding. One day, while he was walking on the banks of the river at Goenoeng Soelit, he came across an animal like an iguana, its body the colour of gold. From its dung he picked out seven pieces of gold, and on following it up he saw it enter a hole in the mountain. Remembering that the animal found by Prince Imbang Djaja was very similar he lost no time in returning with his companion to Tambang Sawah, taking with him the seven pieces of gold. Forthwith Radjah Seti Merat gave orders that the gold should be bought, and that Prince Radjah Ibeng should return to Soelit with enough men to open up a mine (known as the Ketahoen mine to-day) among them being Baginda Kembang Serai (kembang = flower, serai = lemon grass). So Prince Radjah Ibeng began to open up mines, and as work continued numbers of natives came in from round about, and a village was soon established. Meantime Baginda Kembang Serai, following up the Soelit River, commenced mining at a locality named after him Lebong Kambang Serai (lebong or lebang = hole or mine).

About this time Datoek Radjah Sabo was mining at Segalengai, and his son and others, not forgetting an ajam broego, set out on an expedition to Pinang Belapis (pinang = palm and belapis = folded). On arrival there the ajam broego crowed several times. Again a populous village arose as the result of mine development. In the courses of the Ajer Lelangai and Ajer Hoesang mines were opened, and near the latter the pioneer wrote on a certain stone also. Hence to this day there is the name Lebong Bateo Bertoelis, "the mine near the inscribed stone."

At about this time there arrived several men from Bantam. One day Baginda Seligi and his wife, the daughter of the Bantam Chief, were working for gold when they discovered a piece as large as a cucumber, but fearing they might be robbed, they fled with it down the Ajer Simpang (simpang = the meeting place of two or more streams). At a certain spot a gold ring fell into the water, and though they tried for some time they could not find it. Continuing down stream, they stopped for a night near a stone. During the night the woman, pondering over her loss, persuaded herself that perhaps the ring had drifted down stream, so she arose and resumed her search by diving in the water, but without success. However, the runaways stayed at the place and began prospecting, in the hope of finding gold to replace the lost ring. Being successful in their search they built a house, and then returning to Pinang Belapis they told of their discovery. Pinang was abandoned, and a new village. Karang Tjintjin (tjintjin = ring), arose in the course of time on the new spot. It is said that B. Seligi Angin and his wife had two sons, one of whom named Baginda Loeboek Simau (loeboek = deep pool), found the mountain called Simau, and the other one, Baginda Karang Latang, found the mountain that men call Goenoeng Tandai (where the Simau Mining Co. is now working). They are said to have found many gold workings along the banks of the Ajer Seblat and thence to Goenoeng Oeloe Ipoh. It is related that Datoek Radjah Bintang, after a long stay at the mines in Lebong Serang (sarang = nest), set out with some friends to prospect the slopes of Goenoeng Sam, where he found various mines such as Oeloe Oerai and Oeloe Baliman, and built a village called Pelabai, where he resided permanently.

And in the same way, too, Datoek Radjah Siang, leaving Lebong Sarang, journeyed toward the upper reaches of the Ketahoen, and at a certain place, to this day called Lebong Seang, he stopped and built a village and carried on mining operations, as well as at a place called Serdang Koening (koening = yellow). As time went on, the population of Lebong grew, till there were many large and small villages there.

One day a youth named Serapoe Koembang (koembang = beetle) ran away with a girl from Kota Roekan, a village in Lebong district and took refuge in the jungle, pursued by the angry Kota Roekam men. The fugitives abode in the jungle, and one night Serapoe Koembang had a dream. In his dream he thought an old man came to him and said: "Serapoe Koembang! If you wish to escape death from hunger be prepared to follow one of our Siamangs (gibbons) and do not fail to prospect for gold wherever he happens to stop." Acting on this advice, Serapoe Koembang and his companion set out next morning. Arriving at a certain spot they came across a yellow Siamang, and remembering the old man's directions, they set off in pursuit of it. Reaching the branch of a small river, the Siamang jumped into the water and disappeared. Thinking the animal might be the Biang Mas, Serapoe Koembang decided to prospect at that place, and was rewarded by finding plenty of gold. He was soon able to return to Kota Roekam, where he bought the girl's freedom and asked to be married. He afterwards related the nature of his discovery, describing the richness of the hills on the banks of the Ajer Simpang, and having thus persuaded his hearers to accompany him to the Ajer Simpang, he made a stipulation that the mine should belong to them and their descendants to the end. The Simpang mine is worked by the Dutch Government to-day.

The population of Lebong settled down to gold-mining but ultimately Portuguese traders came, directing them to plant coffee, nutmegs and cloves and seek damar (gum), rotan (cane) and rubber (g'tah = gutta) causing the natives to eventually abandon their villag es and mines and remove to the west coast, as the ne w business yielded them larger profits, the mines becoming too difficult to work by the primitive means at their disposal.

CHANCES FOR PETROLEUM AND BITUMENS IN SOUTH AFRICA.

The Department of Mines and Industries of the Union of South Africa has recently established a monthly journal entitled: "*The South African Journal of Industries*." No. 2, published in October, contains an article by Dr. Percy A. Wagner on Mineral Oil, Solid Bitumens, Natural Gas, and Oil Shale. We extract herewith parts of this article relating to the petroleum and solid bitumens. On another occasion we intend to quote his remarks about oil shales. We would mention that an account of Mr. Cunningham Craig's report to which Dr. Wagner refers was given in our issue of April, 1914.

As regards petroleum, a great deal of boring, in most instances quite useless and unjustifiable, has been undertaken within the past thirty years by various oil companies and syndicates. In regard to the Karroo formation in particular high hopes have at different times been entertained owing to the discovery at a number of widely separated points of shows of naturally distilled oil, in and in the neighbourhood of dolerite intrusions. It is even at the present day maintained by some enthusiasts that oil could be struck almost anywhere beneath the Karroo by going deep enough. The fact of the matter, as E. H. Cunningham Craig has pointed out, is that there is only one area in the vast extent of country they occupy, within which the Karroo beds are known to afford some at any rate of the requisite conditions for the formation and accumulation of oil, namely, the so-called Folded Belt in the southern part of the Cape Province; and the only actual evidence that we have of the existence or former existence of oil in the Karroo is furnished by veins of a peculiar coal-like substance that occur in the Laingsburg, Beaufort West, and Fraserburg districts.

Dealing first with the Folded Belt, this is a narrow strip of country, extending along the southern edge of the Karroo from Karroo Poor to the Great Fish River, in which the normally horizontal or almost horizontal Dwyka, Ecca, and Beaufort beds have been sharply flexured with and against the rocks of the Cape system. The carbonaceous White Band shales of the Dwyka series afford a potential source of petroleum. Anticlinal and dome structures, favourable to its concentration of that substance, exist in great number; and an impervious cover for any oil that may be present beneath the surface is supplied by the Ecca shales. No porous reservoir rock is present in the Dwyka or Ecca beds as developed in the area under description, but as it has been proved in the United States that remunerative supplies of oil can be stored in the joints of impervious strata, this in itself does not appear to be a factor of great importance. Except for an alleged show in a well, now dry, on the farm Humefield, not a trace of oil has hitherto been recorded from any of the numerous wells and prospecting pits that have been sunk in different parts of the Folded Belt on the outcrops of the Ecca and Dwyka beds. In view, however, of the many favourable features presented by this tract of country, it was suggested by Cunningham Craig that it might be as well to carry out some detailed investigations. From theoretical as well as practical reasons he recommended that the section of the belt south of Aberdeen, near Jansenville, Saxony, and Klipplaat Station should be examined first, and that if well-marked anticlines or elongated dome structures could be discovered in this area, "the farthest north well-marked anticline or dome should be selected, where the white band of the Dwyka is not less than 1,500 ft. beneath the surface, and a well should be drilled to test the series as far as the white band or even lower." Following on this recommendation a detailed geological survey of an elongated area, extending from the neighbourhood of Prince Albert Road Station to Commadagga Station, and thus taking the whole of the central part of the Folded Belt, was carried out in 1916 by Dr. A. W. Rogers. The main conclusions reached as a result of this work were: (1) that the thickness of the Ecca beds within the area under review is very considerably in excess of previous estimates, being well over 6,000 ft.; (2) that the character of the folding within the tract of country surveyed is such that the Dwyka series is carried deep underground, and is not brought to within 4,000 ft. of the surface in the area north of the main Ecca outcrop; (3) that there are no broad anticlines that bring the Dwyka shales within a moderate distance of the surface in the area of the Beaufort beds examined. The bore-hole, recommended by Cunningham Craig, in order to reach the white band, would therefore have to be carried to a depth of considerably over 4,000 ft.

Quite apart from this, however, and the difficulty of locating the precise position of anticlines and synclines in fairly closely folded strata at so great a distance below the surface, there is another factor that would render drilling in the area highly speculative. This is that, owing to its probable mode of occurrence in joints, and the fact that at great depths the Dwyka and Ecca beds may be and probably are quite dry, oil even if present in these rocks is not necessarily concentrated in the anticlines, whatever may have been the case originally. The selection of the most suitable site for a bore-hole would thus be largely guess-work, and to test the area properly two or three very deep holes would have to be put down, for which in the circumstances there certainly does not appear to be sufficient justification.

It remains to deal with the more direct evidence of the existence or former existence of oil in the Karroo. This, as already indicated, takes the form of fissures —usually vertical or highly inclined, but in some instances, almost horizontal—filled with a peculiar, brittle, lustrous, coal-like substance that is now generally regarded as having resulted from the autopolymerization or condensation of petroleum forced into the fissures from below. The vein-filling approximates in composition and properties to anthracite and semi-bituminous coal, and as there appears hitherto to have been some difficulty in finding a suitable designation for it, the name "pseudo-anthracite" is proposed for the varieties that approach anthracite in character and "pseudo-coal" for those that are more nearly akin to semi-bituminous coal.

Pseudo-anthracite and pseudo-coal stand in much the same relationship to true anthracite and semi-bituminous coal as vein-quartz does to quartzite, and belong to the group of substances that American geologists have termed vein-bitumens. These differ greatly in physical characters and properties and in their behaviour toward such solvents as ether, turpentine, carbon disulphide, and petroleum spirit. At one end of the series are viscid, pitch-like bitumens, and at the other end hard, brittle, coal-like minerals, some of which—for example, wurtzilite and uintaite—appear to be very similar to pseudo-anthracite. The specific gravity of the latter, however, is considerably in excess of that of any of these substances, and it evidently represents a more advanced stage in the condensation of petroleum. In the United States, Trinidad, and Mexico the direct association of veins of this character with productive oil-bearing rocks has, in a number of instances, been established. In other instances it has been shown that the veins represent the channels through which the oil originally present in certain areas has escaped. Thus in the first occurrence of grahamite—a pitch-like bitumen—to be discovered and worked in the United States, that mineral occupied a fissure from 1 to 5 ft. wide which cuts across an anticline covering an exhausted oil-pool, the oil having evidently escaped upwards through the fissure, part of it being converted into grahamite.

The conditions under which "manjak" veins, as he terms them, are formed are well summarized by Cunningham Craig in the following words: Manjak veins occur where a thick series of strata, partly or wholly of impervious material, overlies a source of asphaltic oil, and where, either due to the softness of the superincumbent rock, to contraction owing to partial drying or to earth movement, planes of weakness have been developed, enabling the intrusion of petroleum from below.

Veins of pseudo-anthracite and pseudo-coal occur in the Beaufort beds at a number of widely separated localities in the Laingsburg, Beaufort West, and Fraserburg districts of the Cape Province, all of which, however, it is important to note, are situated along the northern margin of the Folded Belt and within or in close proximity to the southern limit ot the great igneous province characterized by the presence of intrusions of Karroo dolerite. Owing to failure to recognize their true character, the veins have been the cause of a great deal of useless and costly prospecting, the idea having unfortunately become current that the vein-filling is coal that has been forced into the fissures from underlying seams, and that if followed downward these would lead to workable coal deposits.

The most important occurrences known at the present time are those on De Drift and Oudeberg, in the Laingsburg Division, about 29 miles north-west of Prince Albert Road Station and on Ongeluksfontein, Tweefontein, and Varschefontein, situated some miles to the north in the Beaufort West Division. On these farms there is a regular system of vertical veins of pseudo-anthracite that can be followed at the surface over a distance of about 20 miles, the most southerly exposure being situated sixteen miles south of the southernmost outcrops of Karroo dolerite in this area. The "anthracite" has been deposited along persistent, well-defined tension joints in mudstones and clayey sandstones belonging to the Beaufort series, the strike of the joints varying from north and south to N. 12° W. In some instances no appreciable difference in level can be seen in the rocks on either side of the veins, but in others the rocks on the eastern side have been slightly depressed relatively to those on the west. The mineral does not always keep to the same joints when followed downward, but may be seen at various depths to depart horizontally for a few feet and then take a further downward course parallel to the joint plane above but not directly under it.

In the matter of width the veins exhibit great irregularity, the "anthracite" thinning and thickening capriciously from mere films to, in one place, a body 5 ft. in thickness. One of the veins is said to average 2 ft. in thickness over a distance of 500 yards, but this statement lacks confirmation. The larger veins are seen in places to send thin veins and stringers into the country-rock, but, as a rule, the vein-filling makes a sharp, smooth contact with the fissure walls. The latter, however, have often been invaded by black matter from the fissures, so that the country-rock is coloured black for a fraction of an inch or so from the walls, additional proof, if any were needed, that the material now represented by the pseudo-anthracite must have been in a liquid condition when it reached its present position. Inclusions of the wall rocks in the pseudo-anthracite, which are of fairly common occurrence, are similarly impregnated. The pseudo-anthracite in places exhibits a kind of cone-in cone structure, but no trace of lamination or banding parallel to the walls has been discovered in any of the veins. The intrusion and condensation of the petroleum must therefore have been a continuous process.

In its typical development the material filling the veins is a brittle, lustrous, jet-black substance whose specific gravity ranges from 1·35 to 1·47. It is difficult to ignite, and on being heated decrepitates violently. At high temperatures, however, it burns quietly with a very short flame, producing great heat, its behaviour in this respect being similar to that of true anthracite.

The composition of pseudo-anthracite and pseudo-coal from a number of the occurrences described is shown by the proximate analyses in the accompanying table. Analyses of anthracite, semi-bituminous coal, and American vein-bitumens are adduced for comparison.

It will be seen that, as might be expected, the material from different localities exhibits fairly considerable differences in the amount of fixed carbon, volatile matter, moisture, and ash. The differences in the percentage of volatile matter in the pseudo-anthracite and pseudo-coal of different occurrences point to differences in the degree of induration that the material has undergone.

While generally regarded merely as indicators of the

COMPARATIVE ANALYSES OF PSEUDO-ANTHRACITE, PSEUDO-COAL, ETC.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
Moisture	1·00	1·62	5·25	·68	7·46	7·65	3.42	3·66	·25	·09
Volatile matter	4·70	5·83	12·34	19·09	20·83	17·04	4·38	17·47	43·33	23·06
Fixed carbon	91·98	85·32	76·9	80·19	76·2	74·47	83·26	75·95	55·97	75·90
Sulphur	0·27	1·44	1·12	—	·86	—	·73	·96	1·47	1·69
Ash	2·05	7·23	5·51	·80	2·14	·84	8·20	2·92	1·45	·95
Calorific value	14·96	13,800	—	—	12,850	—	—	—	—	—

1. Pseudo-anthracite, De Drift; Analyst, A. F. Crosse. II. Pseudo-anthracite, De Drift; Analyst, W. Versfeld. III. Pseudo-anthracite, Varschfontein; Analyst, W. Versfeld. IV. Pseudo-coal, Leeuw River's Poort; Analyst, Government Laboratory, Capetown. V. Pseudo-coal, Hartebeestfontein; Analyst, Government Laboratory, Capetown. VI. Pseudo-coal Wilgebosch Kloof; Analyst, P. D. Hahn. VII. Anthracite. Mammoth Seam, Pennsylvania. VIII. Semi-bituminous Coal, Cape Lisburne, Alaska. IX. Vein Bitumen (Grahamite), Impson Valley, U.S.A. X. Indurated Vein Bitumen, Black Fork Mountain, U.S.A.

possible existence of workable seams of coal and, more recently, of petroleum, it was hoped that some of the larger veins might in themselves prove to be of economic importance. Of this, however, there is little prospect because, in addition to the inaccessibility of the occurrences hitherto discovered, and the fact that the irregular character of the veins would render prohibitive the cost of developing a sufficiently large tonnage to justify the building of a railway to any of the areas in question, the uses to which the vein-filling can be put appear to be very few. The fact that it decrepitates violently on being heated renders it useless as a fuel for ordinary boilers and locomotives. It might find application in specially designed gas producers, but for this purpose could not under existing conditions compete in price with ordinary anthracite and wood charcoal. The softer and less altered vein-bitumens occurring in the United States and elsewhere are utilized for making varnishes and insulating electric wires, etc., and veins of asphaltite, occurring in the Quisque and Yuali districts of Peru, have acquired considerable importance owing to the fact that they contain up to 5% of carbonaceous vanadium sulphide, patronite. The Karroo fissure anthracite and coal, owing to its highly indurated character, is quite unsuited for the uses to which the softer vein bitumens are put, and that from the De Drift area at any rate contains no vanadium. The only field in which there is a possibility of small quantities of pseudo-anthracite finding profitable application is in electro-chemical processes such as the manufacture of calcium carbide, and as electro-chemical works are at present in course of erection at Germiston, it is very desirable that its suitability for this purpose be tested.

The probable manner of formation of the veins has already been indicated. It remains to consider the origin of the petroleum from the inspissation of which the "anthracite" and "coal" are assumed to have been formed. There are two possibilities: (1) That it was distilled by the heat of great intrusions of dolerite from the White Band or other carbonaceous shales in the Karroo beds. (2) That it was injected into the fissures from reservoirs of oil underlying or originally present below the areas in which the veins occur. As regards the former of these alternatives, it is difficult to avoid connecting the veins with the Karroo dolerites, because, as already pointed out, all the occurrences hitherto discovered, with the exception on those on De Drift and the adjoining farms, are situated within the southern limit of the intrusions, and it is quite possible that there may be dykes or sills deep down below the surface in the De Drift area. As regards the latter alternative there is the well-established association of vein-bitumens with petroliferous rocks in other parts of the world, and also the fact that many important oilfields are analogously situated, adjacent to sharply folded belts, in areas where the folds become progressively broader and more gentle. With the evidence at present available it is impossible to decide which of the two theories is correct, and in view of the uncertainty that prevails as to whether, even in the event of the oil having been derived from pools below the veins, any of the former still contain oil, and, if so, whether in payable quantities, the putting down of one or more very deep bore-holes—they would have to be carried to a depth of fully 6,000 ft. even in the most favourably situated areas to reach the base of the Ecca beds—would at the best be a highly speculative venture.

Another area, in which the possibility of favourable structures being developed in the Karroo beds was suggested by Cunningham Craig is north-eastern Natal and the portion of Zululand contiguous to it. In the tract of country under review, broad monoclinal folds appear to be developed in the Ecca beds, but this in itself of course means nothing, and inasmuch as no indications of oil have been recorded from any of the fairly numerous bore-holes put down in the north-eastern corner of Natal and in the Umlalaas and St. Lucia coalfields in Zululand, the probability of there being a petroleum field in this area appears to be very small. Of other formations in which boring for oil has been undertaken, the Uitenhage beds of the Cretaceous system are deserving of special mention. These strata, a typical littoral and estuarine series, were laid down under conditions very similar to those under which many important oil-bearing formations appear to have been deposited. Unfortunately, however, there are no structures within them favourable to the formation and concentration of petroleum, and a deep bore-hole put down some years ago at Zwartkops went right through the formation without yielding so much as one drop of oil.

Of the older geological formations the Bokkeveld beds, and particularly the lower portion of the series, appear to offer a number of favourable characteristics. It consists of a regular alternation of shales and thin sandstones with numerous marine fossils, and in the country between Touws River and Montagu it is practically certain that broad anticlinal structures are developed in these beds. In the complete absence of any indications of the presence or original presence of petroleum in the Bokkeveld series it would be highly hazardous, however, to undertake boring in this particular area. The only potential source of petroleum hitherto discovered in the pre-Cape rocks of South Africa are certain carbonaceous and bituminous strata occurring in the Malmesbury series in the western and north-western districts of the Cape Province and in the Schwarzkalk beds—the northern correlatives of the Malmesbury series—in the Protectorate of South-West Africa. In the Van Ryns Dorp division of the Cape Province black carbonaceous slates and phyllites crop out below the limestones of the so-called Atics group of the Malmesbury series in the valley of the Troe Troe River. The slates and phyllites are intensely crumpled and sheared, while the overlying limestones, some of which also contain a good deal of carbonaceous matter, are disposed in broad anticlinal folds. No indications of oil have been recorded from this area.

According to Rogers, carbonaceous slates and shales are also developed in the Malmesbury beds at Neint Nababeeb on the Orange River in Little Namaqualand.

At Bethany and, near Kuibis in the South-West African Protectorate, bituminous slaty shales are intercalated with dark limestone in the upper portion of the Schwarzkalk series. These beds, which presumably are also developed in other parts of Great Namaqualand, probably represent the source whence the veins of "fissure coal" occurring in the Keetmanshoop District derived their filling. The "coal" is found under precisely the same conditions as the Karroo pseudo-anthracite in vertical or highly inclined veins intersecting nearly horizontal shales and sandstones belonging to the Fish River beds of the Nama System at several localities.

Summarizing the conclusions reached as a result of this brief survey, it may be said that, while the possibility of the existence of valuable petroleum fields in British South Africa cannot be finally dismissed, the likelihood of any important discovery seems remote.

Leaching with Ammonia.—In our issue of September last, we gave a lengthy extract from a paper describing the plant used at the Calumet & Hecla for extracting copper from tailing containing metal and oxide by leaching with ammonia solution. Another article on the ammonia process recently published gives an account of its application at the Kennecott copper mine, Alaska. This article is by H. M. Lawrence, and appears in the *Engineering and Mining Journal* for November 3. The ore at this mine is partly sulphide and partly carbonate, distributed through limestone. By water concentration a high recovery of the sulphide minerals is obtained, and about 60% of the carbonate is also extracted in this way. The tailing averages 1·2% of carbonate of copper. The novelty in this installation consists in the use of steam for washing the tailing after leaching. This method was adopted chiefly on account of the scarcity of water at Kennecott, but also in order to avoid the dilution of the solutions. The first plant erected has a capacity of 300 tons per day. Four leaching vats, each 30 ft., with a leaching column 15 ft. high constituted this first section of the plant. An 800 ton plant is now under construction. The tailing is partly de-slimed before being charged into the vats. The leaching solution is kept in circulation for about 30 hours. The author's description of the subsequent washing operations is as follows:

The leaching solution is drained off, part going to the evaporators, and part reserved as make-up for the next charge. While this rich solution is being drawn off from the bottom of the vat, about 20 tons of weak copper-ammonia solution is pumped on top of the charge as a preliminary wash and follows the rich solution down through the charge. When this weak solution begins to appear at the bottom of the vat, the effluent is turned over from the rich-solution storage tank to the wash-solution storage tank. Immediately following the preliminary wash comes the steam wash. Steam is admitted at the top and gradually heats the charge to the bottom. The pressure in the vat is kept below 5 lb. per sq. in. to avoid distorting the vat and subsequent leakage. The incoming steam condenses in heating the charge, so that a film of condensed water precedes the steam down through the vat, displacing most of the copper-ammonia solution. The remainder of the ammonia, volatilized by the steam, is carried out with it after it reaches the bottom openings in the vat, and is re-condensed in a special condenser. This weak ammonia solution is saved in the wash-solution storage tanks. When the ammonia content of the vapours issuing from the vat has fallen to 0·5% NH_3, the wash is considered finished; the steam is shut off and the vat excavated with mechanical excavators. The time necessary for steam washing, when carried out in connection with the preliminary wash with weak solution, will average 20 hours per charge and the steam used amounts to about 100 lb. per ton of material leached.

The steam wash is the greatest single factor in making the Kennecott leaching a success, and upon this portion of the process a patent has been granted. This method of washing makes it possible to leach rich ores with concentrated ammonia solutions, without incurring an excessive ammonia loss in the tailing, or without using a large volume of wash water, probably several times the volume of the leaching solution, instead of 20% of it as with the steam wash. The steam economy arising from distillation of solutions which contain upward of 4% copper more than counterbalances the steam used for the wash. In addition, there is the advantage that these rich solutions have little tendency to encrust the walls of the evaporators and stills.

The cost of the steam is the most considerable factor in the process. The cost per lb. of copper recovered is divided thus: steam 2·24 c, ammonia 1·13 c, labour 0·93 c, power, maintenance, etc., 1·47 c, total 5·77 c. The cost per lb. of NH_3 is 34 c, and the ammonia loss is about 0·5 lb. per ton of ore treated. The yield of copper per ton of ore is about 15 lb., equal to a 75% extraction.

Zinc Refining.—During the last three years the demand for pure zinc, particularly for the manufacture of brass for cartridge making as required by the British War Office, has caused the American zinc producers to establish refineries wherein to treat their lower grade products and second and third drawings from the zinc retorts. L. E. Wemple, metallurgist for the American Zinc, Lead, & Smelting Co., describes some of the methods introduced for this purpose, in a paper to be read at the February meeting of the American Institute of Mining Engineers. In particular he describes the De Saulles process of re-distillation. This process is an adaptation of the Holstein-James method introduced in America twenty years ago. The Holstein-James patent consisted of re-distilling the zinc from impure spelter charged into an inclined retort having the butt end about 4 in. lower than the mouth. The spelter was charged into the retorts in the form of bars. As soon as the spelter melted, the lead, owing to its greater specific, gravity settled out and collected in the lower part of the retort at the butt end. The retorts were carefully maintained at the temperature at which zinc volatilizes, but below that at which lead volatilizes. The furnace for carrying on this operation consisted of a single unit; this is to say, the back wall, which in the case of the ore-smelting furnace is a centre wall and supports the rows of retorts on each side, was an outside wall with openings opposite the butt end of the retort. These openings were for the purpose of cooling the metal in the butt end of the retort, thereby diminishing the ebullition at this point and giving a quiescent condition to the molten metal which promoted the settling-out of the lead. By lowering the temperature of the metal in the butt end to below the volatilization point of lead, this chilling also prevented the lead from going over with the zinc. Besides chilling the butt end of the retort by exposing it to the air, air might be introduced into the combustion chamber through a hole in the brickwork surrounding the butt end of the retort and directly under the retort, or the butt end of the retort might be cooled by means of a water-jacket in the furnace wall. An ordinary conical condenser was temporarily luted into the mouth of the retort for condensing and collecting the distilled zinc. These condensers were provided with a semicircular bridge wall or dam at their large end, to prevent the boiling metal in the retorts from slopping over into the condenser, and also to prevent pure molten zinc in the condensers from flowing back into the retort. The nose of the condenser was partly stuffed.

Two methods are now extensively used for carrying on the re-distillation of zinc in a manner similar to the Holstein-James process. The older method makes use of an ordinary smelting furnace block; the later method invented by C. A. H. de Saulles (U.S. Patent 1,215,007 February 6, 1917), uses a single furnace with back wall exposed.

The De Saulles process uses a specially constructed furnace equivalent to one side of an ordinary furnace block. The retorts are inclined about 7 in. in their length and extended through the back wall 4 to 5 in. An opening is provided at the top of the protruding butt end through which the retort is charged with molten spelter; at the bottom of the butt end a small opening is provided through which the leady bottoms are tapped out; both openings are tightly closed with clay except when charging and tapping. The condenser used is of the ordinary shape and size and is clayed into the retort. The furnaces are fired with natural gas or coal, Belgian style, using a thin flame and natural draught. The furnaces are 2, 3, and 4 rows high and contain from 80 to 200 retorts. Each retort distilling furnace is served by one 25 ton re-melting furnace and one 25 ton equalizing furnace; the three furnaces are built close together and comprise a re-distillation unit. One equalizing furnace may be dispensed with by operating two units together. The spelter to be re-distilled is melted down in the re-melting furnace, where a large part of the lead settles out. After settling, the metal is drawn off from the top of the molten bath into a ladle by cutting down a clay retaining dam. A ladle suspended from a trolley is moved along the back wall of the retort furnace, and by means of a chain block is raised and lowered to the necessary height for emptying its contents into the butt end of the retort. The retorts are charged in this manner once in 24 hours; the two top rows at 7 a.m. and the two bottom rows at 7 p.m. The charge openings are closed with clay packing immediately after pouring in the metal, and distillation of the zinc is resumed with a minimum delay, as the furnace is maintained at a uniform heat throughout the 24 hours. The condensers are drawn every 4 hours. Great caution is exercised in spiessing the stuffing before drawing in order to avoid the spurt of zinc and blue powder caused by the high gas pressure frequently occurring in the condenser. The draw ladle containing the re-distilled zinc is moved along an overhead trolley to the equalizing furnace where its contents are emptied. The equalizing furnace serves the purpose of cooling the overheated metal from the condensers, and blends the metal from the various draws into car lots of uniform spelter. This furnace is drawn during the day shift only, the metal being drawn off into a ladle by cutting down the retaining dam at the surface of the metal. The refined spelter is transferred on an overhead trolley to the mould racks and cast into finished plates of high-grade spelter. The leady metal is tapped once in 48 hours, half of the retorts being tapped each 24 hours; about 20 lb. is removed from each retort. Every 10 days the retorts are tapped completely dry, and the leady metal obtained is returned to the re-melting furnace. The tapping operation takes place about 2 hours before charging, in order that the lead returned to the re-melting furnace may have time to settle out and may not be returned with the next charge metal. Every 2 or 3 weeks the accumulation of lead settling in the bottom of the re-melting furnace is tapped out through a bottom tap and cast into moulds. This lead containing 1 to 2% of zinc is shipped to lead refiners. All re-distilled scrap is returned to the equalizer and leady scrap to the re-melter. Blue powder, dross, and skimmings are re-smelted on the ore furnaces.

The spelter ordinarily charged to re-distilling operations consists of second and third draw metal and contains 1·5 to 3% lead, 0·03 to 1·0% iron, and 0·03 to 0·07% cadmium. In the De Saulles method the preliminary settling in the re-melting furnace results in metal carrying about 1% only of lead and 0·03 to 0·05% of iron being charged into the re-distilling pots. The re-distilled spelter contains from 0·03 to 0·12% lead, 0·008 to 0·012% iron, and 0·03 to 0·07% cadmium, averaging 0·10% lead, 0·01% iron, and 0·04% cadmium.

Potash from Felspar.—At the meeting of the Institution of Mining and Metallurgy held on December 20, E. A. Ashcroft presented a paper entitled "A Neglected Chemical Reaction and an Available Source of Potash." The reaction to which he referred consists of heating potash felspar with common salt at a temperature of 900 to 1,000°C. out of contact with air or moisture. The result of this reaction is the replacement of the potash in the felspar by the sodium in the salt, and the production of potassium chloride. Mr. Ashcroft records that an American patent was obtained in 1913 by E. Bassett for this reaction, but that the patent expressly mentioned the presence of air as being requisite. The absence of air and moisture constitutes Mr. Ashcroft's claim for originality. He proceeds to describe plant applicable to the process, and he calls attention to pegmatite in the north-west of Sutherland that would yield large amounts of potash felspar suitable for his process.

Leaching Low-Grade Copper Ores.—In the *Mining and Scientific Press* for November 24, Courtenay De Kalb describes the leaching method adopted at the Copper Queen mine, Arizona, for treating ore containing less than 1% copper. The method is similar to that of the old leaching floors well known in the south of Spain, the copper being removed by the acid generated from the sulphide when the ore is placed in heaps and watered, and then precipitated from the solution by scrap iron. The Copper Queen installation has been designed by Joseph Irving, who has introduced many improvements in the precipitation plant.

Electric Furnaces for Non-Ferrous Metals. — A paper was read by Dwight D. Miller at the autumn meeting of the American Institute of Metals reviewing the present progress and development of the electric furnace in non-ferrous metallurgy. Among the furnaces mentioned are the Gillett, Conley, Thomson-Fitzgerald, Northrup, Hering, Ajax-Wyatt, Foley, Baily, Rennerfelt, Snyder, and Hoskins. Most of these furnaces are applied for melting rather than smelting.

Copper Refining.—In *Metallurgical and Chemical Engineering* for November 15, Lawrence Addicks discusses the modern applications of fire refining to copper, that is to say, the preliminary refining of blister copper before it goes to the electrolytic department, and the final refining and casting of the cathodes into suitable commercial shapes.

Leaching Copper Concentrates. — In the *Mining and Scientific Press* for November 17, A. E. Drucker discusses a plan for treating copper concentrates by roasting and leaching on the spot instead of smelting. The plan is an extension of the method much adopted recently at gold mines, where auriferous pyritic concentrates are treated with cyanide, with or without roasting, instead of being sold to smelters as before. He is of opinion that table and flotation concentrates of copper ores will in the same way be treated more profitably to the mine owner by leaching and electro-deposition.

Recovering Fume.—In the *Mining and Scientific Press* for October 27, L. S. Austin describes the Cottrell dust-precipitating installation at the converter plant, Tooele, Utah. It is used to catch lead fume given off in the treatment of leady copper matte in the converter, the matte being a product of the lead blast-furnace.

Dust-Catching.—In *Metallurgical and Chemical Engineering* for November 15, John Ruddiman describes a new method of extracting dust from blast-furnace gases.

Electrolytic Zinc. — At the October meeting of the American Electro-Chemical Society, Thomas French read a paper on the future of electrolytic zinc. He sees a large application for the electrolytic process in connection with complex ores from which other contents have been extracted.

Flotation.—In the *Mining and Scientific Press* for October 27, Wilton Shellshear writes on preferential flotation.

Flotation Litigation.—In the *Engineering and Mining Journal* for December 1, R. C. Canby, who is associated with the Miami Copper Co., reviews recent patent litigation in connection with flotation, more particularly the Miami and the Butte & Superior cases.

Titanium Ferro-Alloys.—The *Engineering and Mining Journal* for November 24 reprints a paper on titanium ferro-alloys by R. J. Anderson.

Ferro-Manganese.—In *Metallurgical and Chemical Engineering* for December 1, E. C. Buck gives a bibliography on the manufacture of ferro-manganese, beginning with the year 1877.

Drift-Mining in California. — In the *Engineering and Mining Journal* for November 17, J. D. Hubbard describes the methods of mining gold-bearing gravels that are covered with recent lava-flows.

Dangerous Hanging Walls.—At the December meeting of the Midland branch of the National Association of Colliery Managers, J. W. Case read a paper on the working of coal seams that have dangerous roofs.

Lining Shafts.—The *Iron & Coal Trades Review* for December 28 describes the system of concrete block lining for shafts introduced by Frederick Walker, of Doncaster.

Safety of Winding Ropes.—The November *Journal* of the South African Institution of Engineers contains a paper by J. A. Vaughan on the factor of safety of wire ropes used in winding at mines.

Air-Lift Pumping.—At the November meeting of the Instutition of Mechanical Engineers, A. W. Purchas read a paper on air-lift pumping. He presented a new theory of the action of the air lift, and made suggestions for the improvement of its efficiency.

Loading Iron Ore.—In *Engineering* for December 28, G. F. Zimmer describes the iron ore loading plant at Bilbao, built by Fraser & Chalmers for José McLennan.

Molybdenite in Canada.—In the *Canadian Mining Journal* for December 1, J. S. De Lury describes molybdenite deposits at Falcon lake, Manitoba.

Arbouin Copper Mines, Queensland. — In the *Queensland Government Mining Journal* for October 15, Lionel E. Ball describes the Arbouin copper mines at Cardross, 20 miles west of Mungana, North Queensland. These mines were worked by the Manmoth Copper Co., of Glasgow, before the war.

Phillips River, Australia.—The Proceedings of the Australian Institute of Mining Engineers, September 30, contains an article by M. R. M'Keown on the Phillips River gold and copper district in the southern part of West Australia.

Collahuasi Copper Mines. — In the *Engineering and Mining Journal* for November 24, P. T. Bruhl describes the copper mines at Collahuasi, Chile, worked by the Société Francaise des Mines de Cuivre.

Nitrogen. — *Metallurgical and Chemical Engineering* for November 1 contains a translation of a paper by S. Nauchkoff, read before the Swedish Technological Society, entitled: "How do the Warring Nations obtain their Nitrogen Supply?"

Australian Transcontinental Railway.—In *Engineering* for December 28, E. A. Box describes the building of the Australian transcontinental railway connecting Kalgoorlie with Port Augusta, giving a number of characteristic illustrations.

Colloid Chemistry.—The *Journal of the Franklin Institute* for December contains a paper by H. N. Holmes on the formation of crystals in gels. This is a convenient historical summary of the work done so far.

RECENT PATENTS PUBLISHED.

13,985 of 1916 (110,776). C. ELLIS, New York. In the production of sulphuric acid by the contact process, using as a catalyser a mixture of chromium oxide with oxides of lead, antimony, tin, or cadmium.

16,166 of 1916 (110,948). C. J. INGLIS, Hobart, Tasmania. A method of treating complex sulphide ores in an atmosphere of mixed hydrochloric acid and chlorine gases.

17,138 of 1916 (110,970). G. C. FRICKER, Luton. Refining low-grade zinc, by distilling and passing the vapours through coke placed on the top of the charge of zinc, thereby catching the impurities such as lead.

17,621 of 1916 (110,977). J. F. LOBB, London. Improved form of sluice-boxes for treating alluvial ores, the boxes being built in sections capable of reciprocating motion, and being provided with means of discharging the accumulated concentrate through doors in the bottom.

499 of 1917 (111,377). W. MAUSS, Johannesburg. A centrifugal method of concentrating ores, whereby the heavier portions of the ore are allowed to discharge centrally. This process was mentioned by our Johannesburg correspondent in the issue of February, 1917.

1,295 of 1917 (111,580). UTLEY WEDGE, Ardmore, Pennsylvania. Improvements in roasting furnaces, whereby repairs of the hearths and rabbles are facilitated.

17,708 of 1916 (103,290). E. W. JUNGNER, Kneippbaden, Sweden. A method of producing potash compounds and hydraulic cement, by heating felspar with carbonate of lime and carbonaceous matter.

3,449 of 1917 (111,605). D. and A. SIMPSON, London. A method of distilling oil-shale whereby the sulphur content is eliminated.

COMPANY REPORTS

Sulphide Corporation.—This company was formed in 1895 to purchase the Central mine at Broken Hill and to treat the ores by E. A. Ashcroft's leaching and electro-deposition process. On this process not proving suitable, reversion was made to mechanical concentration in order to extract a lead concentrate. Subsequently the Minerals Separation flotation process was adopted for extracting a zinc concentrate. A lead smelter was established at Cockle Creek, New South Wales. A subsidiary, the Central Zinc Co., was formed to smelt zinc concentrate at Seaton Carew, Durham, and recently that company has been absorbed. The report for the year ended June 30 last shows that 167,210 tons of ore was raised and sent to the lead concentrators, where also 41,374 tons of custom ore was treated, most of which came from the Junction mine. The average assay of the Central ore was 15·1% lead, 17·3% zinc, and 13·1 oz. silver, and of the Junction ore 13·1% lead, 7·7% zinc, and 8·8 oz. silver. At the lead mill 38,637 tons of concentrate was produced averaging 63·4% lead, 8·5% zinc, and 41 oz. silver. In the zinc section there was produced 55,990 tons of zinc concentrate averaging 47·3% zinc, 5·7% lead, and 12·6 oz. silver, together with 2,789 tons of lead concentrate averaging 59·3% lead, 13·5% zinc, and 39·1 oz. silver. It is notable that in the lead section the cascade system of flotation has replaced the tables and vanners. No important development was done during the year at the mines. The reserve is estimated at 1,692,000 tons. A cross-cut is being driven from the Kintore shaft at the 1,400 ft. level to intersect the ore-body. At the Cockle Creek works the lead bullion produced was 27,718 tons, containing 29,296 oz.

gold and 2,273,102 oz. silver. The refinery for treating this bullion was completed in November. The lead is now being sold to the Ministry of Munitions, the silver to the Indian Government, and the gold delivered to the Australian mint. A copper-leaching plant has been added for treating copper matte and purchased copper ores. An electrolytic zinc plant has been erected and is producing zinc from zinc oxide, the zinc being used in the desilverization process. Eventually this plant will be employed in extracting zinc from accumulated slags. At the sulphuric acid works 8,611 tons was produced, and at the superphosphate works 14,077 tons. The Mond gas plant yielded 739 tons of sulphate of ammonia and 243,732 gallons of tar. At Seaton Carew 13,478 tons of concentrate and other material was treated for a yield of 4,419 tons of zinc, 146 tons of zinc dust, and 24 tons of metallic lead, together with 3,461 tons of silver-lead residues. The works are now being doubled, to a yearly capacity of 30,000 tons of concentrate. The accounts show a working profit of £581,891. After allowing £163,285 for taxes, and £134,263 written off capital expenditure, a net balance remained of £286,315. The dividends were 25% on the preference shares of £1 each, absorbing £150,000, and 25% on the ordinary shares of £1 each, absorbing £112,500.

Frontino & Bolivia Gold. — This company was formed in 1864 to acquire gold mines in Colombia, South America. It was reconstructed in 1886, and again in 1911, on the latter occasion Pellew-Harvey & Co. becoming consulting engineers. The report now issued covers the year ended June 30 last. During this period, 23,642 tons of ore, including 6,537 tons of development ore, was sent to the mill; 17,461 oz. of gold was recovered in the stamps, 733 oz. by pan amalgamation, 23,52 oz. by cyanide, and 107 oz. in slags, etc., making a total of 20,653 oz. or 17·47 dwt. per ton. The ore reserve has been substantially increased, standing at 64,300 tons averaging 18 dwt. per ton, as compared with 26,106 tons averaging 20·4 dwt. the year before. The accounts show an income of £91,323 from the gold produced, and £7,810 from tributers' gold. The net profit was £18,560, out of which £4,513 was paid as debenture interest, £2,339 as 10% preference dividend, and £14,000 as dividend on the ordinary shares, at the rate of 10%.

Champion Reef.—This company was formed in 1889 by John Taylor & Sons to acquire a gold-mining property adjoining the Mysore mine, at Kolar, Mysore State, South India. The prosperity of the company continually increased until 1905. Since that year the average content of the ore sent to the mill has been very much lower, and the profits and dividends have suffered accordingly. During the last two years the developments at depth have been unfavourable, and the reserve has fallen seriously. It has been found necessary, therefore, to reduce the output of ore. The report for the year ended September 30 last shows that 149,612 tons of ore was raised and sent to the stamp-mill, as compared with 194,311 tons during the previous year, and 240,987 in 1905, the year of maximum prosperity. The yield of gold by amalgamation was 85,475 oz. At the cyanide plant 200,616 tons was treated for a yield of 17,118 oz. The total production of gold was 102,593 oz., realizing £435,111. During the previous year the production was worth £499,511, and in 1905 the yield was worth £825,263. The yield per ton of ore milled was 1⅜ dwt. higher than during the previous year, and that from the cyanide plant 0·3 dwt. higher. The working cost was £267,136, appropriation for income tax £13,679, allowance for depreciation, etc., £28,924, and £5,000 was placed to reserve. The shareholders received £104,000, the dividend being at the rate of 40%, the same as last year, and comparing with 160% in 1905. In judging of the rate of dividend, our remarks in the Editorial in the December issue relating to shares being issued at a premium must not be overlooked, for, of the £260,000 nominal capital, £200,000 was issued at par on the original formation of the company, while shares nominally worth £55,000 were issued, for the provision of working capital, at £427,000. During the year developments have been continued in the Glen and Carmichael sections, the auxiliary shafts being sunk 357 ft. and 354 ft. respectively. No improvement can be reported in Carmichael's section, but in the Glen section the ore developed between the 51st and 54th levels has been fully equal to the ore raised during the year. The indications, however, are that unless favourable developments occur shortly a further reduction in the monthly output will be necessary. The reserve now stands at 351,255 tons, as compared with 375,991 tons a year ago.

Malayan Tin Dredging.—This company was formed in 1911 to acquire alluvial tin lands near Batu Gajah, in the Kinta district of Perak, Federated Malay States. Nutter & Pearse reported on the properties, F. W. Payne & Co., designed the dredges, and A. C. Perkins is manager. The company belongs to the same group as the Tronoh, Lahat, and Sungei Besi companies. The report for the year ended June 30 last shows that all four dredges were continuously at work. The total ground dredged was 3,141,300 cubic yards, and the output of tin concentrate was 871·8 tons. The yield per yard was 0·61 lb., as compared with 0·7 lb. the year before. The concentrate sold for £97,681, and the balance of profit was £32,353, after allowing £10,504 for depreciation. The shareholders received £24,200, being at the rate of 20%. Operations were hindered by the difficulty in obtaining spare parts, particularly buckets, and the amount of ground treated was in consequence rather less than the year before. Moreover the costs increased all round. During the year, 13 acres of additional ground was acquired, bringing the total to 1,223 acres. The area exhausted so far is 135 acres.

Pahang Consolidated.—This company was formed in 1887 as the Pahang Corporation to acquire land containing tin lode mines in the state of Pahang, Federated Malay States. In 1906 the properties of the Pahang-Kabang and Malayan Exploration companies were absorbed, and the name was then changed and additional capital subscribed. In 1909 the scale of development was expanded, on the advice of William Frecheville, and further funds were provided for this purpose. The results obtained since then have been excellent. The report for the year ended July 31 last shows that 156,700 long tons of ore was mined and sent to the mill. The yield of tin concentrate was 2,656 tons, or 1·69% of the ore milled. In addition 115 tons of tin concentrate was won from alluvial workings. The accounts show an income of £327,428 from the sale of concentrate, and a working profit of £135,681. Out of this, £20,000 was placed to reserve and £20,751 was written off for depreciation and from shaft-sinking account. The rubber estate brought a net profit of £24,857. The net profit of the company for the year was £119,786, out of which £15,000 has been paid on the preference shares, being at the rate of 15%, and £78,374 on the ordinary shares, being at the rate of 20%. J. T. Marriner, the manager, gives details of developments throughout the great ramifications of workings. Willink's and Nicholson's lodes continue to yield high-grade ore. On the 800 ft. level the aggregate length of ore-shoots is over 700 ft. and the assay-value is 3%. It is considered inadvisable at present to sink deeper on the lodes as an inflow of water is expected and there are no pumps available for handling it. The reserve is estimated at 500,000 tons, and the prospects of finding further ore continue to be favourable.

Chendai Consolidated.—This company belongs to the Wickett group, of Redruth, and was formed in 1914 as a consolidation of the Redhills, Sungei Chendai, and Chendai Lodes companies, operating alluvial and lode tin mines in the Kinta district of Perak, Federated Malay States. The report for the year ended April 30 shows that at the Chendai lode mine 6,981 tons of ore was sent to the stamps, for a yield of 44½ tons of tin concentrate, selling for £4,863. The Katcha and Chendai alluvial properties were let on tribute, the yields being 40 tons and 53 tons respectively, on which the company's royalties were £448 and £614. The costs at the Chendai lode mine were £4,744. The company's net profit for the year was £277, as against a debit balance of £408 brought forward from last year.

Rambutan.—This company belongs to the Redruth group; James Wickett is chairman and Osborne & Chappel are the managers. It was formed in 1905 to work an alluvial tin property in the northern part of the Kinta district of Perak, Federated Malay States. A pump-dredge was used at first, but hydraulic elevating and sluicing was substituted later. The report for the year ended June 30 last shows that 580,000 cubic yards of ground was treated for a yield of 259 tons of tin concentrate, being an extraction of 1 lb. per yard. The income from the sale of concentrate was £28,759, and the net profit was £19,083, out of which £13,333 was distributed as dividend, being at the rate of 13⅓%.

Benue (Northern Nigeria) Tin Mines.—This company was formed in 1910 to acquire alluvial tin properties in the Zaria district, North Nigeria. It was reconstructed in 1911 and 1915. Operations were started by bucket-dredge, but the ground proved unsuitable and the dredge was sold. Tin is now won by calabashing. The report for the year ended July 31 last shows that the output of concentrate was 200 tons, which sold for £33,003. The net profit was £11,833, out of which £5,000 has been placed to reserve, and £6,000 has been declared as dividend, being at the rate of 10%. The shares are 9s. 6d. paid, and in order to extinguish the 6d. liability, this amount is now being called up and set against the distribution of dividend.

Forum River (Nigeria) Tin.—This company was formed by the Northern Nigeria Trust in 1912 to acquire alluvial tin ground on the Forum, Du, and Bukeru rivers, Northern Nigeria. Arthur W. Hooke is the manager. The report for the year ended March 31 last shows that 325 tons of tin concentrate was won. The accounts show credits of £40,716, and a net profit of £13,267. Out of this, £5,000 has been placed to reserve and £8,156 has been distributed as dividend, being at the rate of 15%. The cost at the mine was £60. 6s. 6d. per ton, and the all-in cost was £114 8s. 4d.

Northern Nigeria (Bauchi) Tin Mines.—This company was formed in 1910 to acquire alluvial tin properties at N'Gel in Nigeria from the Anglo-Continental Mines Co. The report for the year ended June 30 last shows that 555 tons of tin concentrate was won, as compared with 565 tons the year before. The accounts show credits of £85,975 and a net profit of £26,779. The preference shares received £22,099 or 17½%, and the ordinary shares £7,292 or 7½%, as dividends. Boring of the N'Gel flats has been continued, and ground estimated to contain 3,642 tons of cassiterite has been proved, bringing the total assured cassiterite to 6,876 tons. In addition a new deep lead has been discovered. As recorded a year ago, gravel-pumping has recently been adopted in addition to sluicing. It is now intended to extend this method of mining, and in order to secure the necessary electric power a lease of the Kwall Falls has been obtained. By means of a dam above the falls, a power supply of 1,400 h.p. will become available. A. R. Canning, the manager, recently resigned to join the Forces, and he is succeeded by E. J. Andrews.

Sheba Gold.—This company was formed in London in 1887 to acquire from a local company a group of gold-mining properties at Barberton in the eastern Transvaal. Dividends were paid from 1891 to 1898, and then came a series of disappointing years. The company was reconstructed in 1904 and 1911. Dividends were again paid from 1911 to 1915, but since then the reserves and the grade of the ore have decreased seriously, and the present outlook is gloomy. The report for the year ended June 30 last shows that 78,940 tons of ore averaging 8·83 dwt. was raised and sent to the mill; of this ore 14,764 tons averaging 10·7 dwt. came from the Zwartzkopje, 57,460 tons averaging 8 dwt. from the Incombi and Southern Cross, and 6,716 tons averaging 11·88 dwt. from the Insimbi. The total yield of gold was 23,171 oz. worth £97,844. The result of the year's operations was a loss of £10,266. The ore is refractory, and the percentage of recovery is only 67%. Additional concentrating and roasting plant has been provided recently with a view to improving the extraction. The ore reserve is estimated at 94,800 tons averaging 6·5 dwt. A large amount of development has been done during the year at the mines mentioned, and also at some others of the group.

Pigg's Peak Development. — This company was formed in 1889 to acquire a tract of country near Pigg's Peak, in Swaziland, South Africa. Operations have been confined to the Peak gold mine, which has not so far proved a profitable venture. There have been two reconstructions, the last being in 1898, when L. Ehrlich & Co. assumed control. In addition to these reconstructions, capital has been subscribed on two occasions, in 1905 and 1909. The report for the year ended March 31, 1917, shows that 24,152 tons was sent to the mill, and that gold worth £20,173 was extracted. The expenses exceeded the income by £6,294. As the ore reserves became depleted and the grade of the ore sent to the mill decreased, milling was suspended and attention devoted to the development of further supplies of ore. Harold Sharpley resigned as manager, and was succeeded by Joseph Jennings. Mr. Jennings has prospected on three levels and has developed about 30,000 tons averaging 6 dwt. per ton. On the 5th level, a length of 102 ft. was in ore averaging 8·6 dwt.

Simmer & Jack Proprietary Mines.—This company belongs to the Consolidated Gold Fields group, and was at one time a leading producer on the Rand, though the grade of the ore was always lower than that of the best mines in the central Rand. The report for the year ended June 30, shows that 776,463 tons of ore was raised, and after the rejection of 1·87% waste, 765,300 tons was sent to the mill. The yield of gold was 196,096 oz. worth £819,078, being 5⅓ dwt. or 21s. 4d. per ton milled. The working cost was £591,891 or 15s. 5d. per ton, leaving a working profit of £227,187, or 5s. 11d. per ton. The dividends absorbed £225,000, being at the rate of 7½%. Only a small amount of development remains to be done in the property, but the life of the company has been prolonged by the purchase of 40 claims from the adjoining Simmer Deep. The reserve of fully developed ore is estimated at

1,862,000 tons averaging 5·3 dwt., together with 401,000 tons of partly developed ore having an indicated average of 4·78 dwt.

Sub-Nigel.—This company was formed in 1895 to acquire property on the dip of the Nigel mine in the Heidelberg district, on the southern side of the Far East Rand basin. In 1909 the adjoining property of the Nigel Deep was absorbed. The control is with the Consolidated Gold Fields. In recent issues we have given details of the proposed expansion of operations at this mine. The report for the year ended June 30 last shows that 183,319 tons of ore was mined, and after the rejection of 24% waste above and below ground, 110,280 tons was sent to the mill. The yield of gold was 58,283 oz., worth £242,907, being 10·57 dwt. or 44s. per ton milled. The working cost was £179,476, or 32s. 6d. per ton, leaving a working profit of £63,430, or 11s. 6d per ton. The dividends absorbed £53,947 or 12½%. The reserve is estimated at 359,000 tons averaging 10·4 dwt., together with 31,000 tons of partly developed ore having an indicated assay-value of 9·4 dwt. The figures for the reserve show an increase of 145,000 tons and 1·3 dwt. as compared with those of a year ago.

Luipaard's Vlei Estate & Gold.—This company was formed in 1888 by the Consolidated Gold Fields to work a gold-mining property in the far west Rand. Milling started in 1898, but was suspended on the outbreak of the Boer war, not to be resumed until 1906. In 1909 the adjacent Windsor mine was absorbed. The control passed in 1912 to L. Ehrlich & Co. The property consists of four sections, two on the Main Reef Series, and two on the Battery Reef to the south. Small dividends were paid in 1908, 1909, and 1916. The report for the year ended June 30 last shows that 322,776 tons of ore was raised, and after the rejection of waste, 251,529 tons averaging 5·34 dwt. per ton was sent to the mill. Of the ore raised, 182,861 tons came from the Main Reef stopes, 68,884 tons from the South Reef stopes, 37,436 tons from the Battery Reef stopes, and 33,595 tons from development faces. The yield of gold was 65,373 oz. worth £271,904, being 5·2 dwt. or 21s. 7d. per ton milled. The working cost was £252,309, or 20s. per ton. Revenue from the estate, and other items, brought the total receipts to £283,221. The net profit was £24,825, out of which £10,633 was written off for depreciation, and £11,800 was paid as dividend, being at the rate of 2½%. The company has a large balance to the credit of profit and loss account, £126,157, but this is represented by additions to equipment made during recent years and is not distributable as cash. The reserves are estimated as follows: Main Reef 565,547 tons averaging 5·38 dwt., South Reef 164,531 tons averaging 5·6 dwt., and Battery Reef 62,311 tons averaging 5·93 dwt. The ore in the Battery Reef is of rather higher grade than that in the Main Reef Series, but the ground is much faulted.

Middleburg Steam Coal & Coke.—This company was formed in 1902 under Cape laws to acquire coal lands in the Middelburg district of the Transvaal. It was reconstructed under English laws in 1906. The company is a subsidiary of the Mount Yagahong Exploration and Finance Co. Alan Cadell is chairman, A. T. Macer is managing director, and E. M. Goodwin is mine manager. The report for the year ended June 30 last shows that 309,555 tons of coal was raised, an increase of 12,331 tons as compared with the previous year. The net profit for the year was £17,161, out of which £5,000 has been placed to reserve, £3,244 paid as 5% preference dividend, and £9,988 on the ordinary shares, being at the rate of 10%. The arrangement with the Transvaal Coal Owners' Association provides for the increase of the monthly output from 17,100 tons to 26,800 tons in July next. The property of the company has been increased recently by the acquisition of the Zondagsvlei, in conjunction with the Mt. Yagahong company. This property is 20 miles nearer Johannesburg than the present mine.

Witbank Colliery.—This company was formed in 1896, to acquire coal deposits in the Middelburg district of the Transvaal, about 90 miles east of Johannesburg. The sale of coal commenced in 1898, and increased gradually until 1909, since when the yearly output has been fairly regular. The control passed from Neumann's to the Central Mining & Investment Corporation in July, 1917. The report for the year ended August 31 last shows that 514,204 tons of coal was despatched from the Witbank colliery and 373,127 tons from the Uitspan colliery, a total of 887,331 tons. Of this, 447,473 tons from the Witbank, and 316,512 tons from the Uitspan was screened coal and the remainder "duff." The accounts show a working profit of £84,492, out of which £52,500 has been distributed as dividend, being at the rate of 25%.

Welgedacht Exploration.—This company was formed in 1899 to acquire property in the Far East Rand, east of Modder East and north of Grootvlei. In 1905 the banket beds were proved by bore-hole, but shaft-sinking to reach them has not been completed owing to water troubles. Operations have been confined to working the coal seams in the shallower levels. The report for the year ended June 30 last shows that 150,636 tons of coal was sold, as compared with 127,106 tons the year before. The net profit for the year was £4,429, out of which £3,918 was paid as dividend, being at the rate of 2½%. During the year the new shaft, sunk in a more convenient position, came into service. The old shaft, originally intended to meet the banket, is now used only for pumping purposes. No doubt when the opportunity arises, sinking will be resumed.

Cam & Motor.—This company belongs to the Weil group, and was formed in 1910 to acquire gold mines at Gatooma in Rhodesia. Operations are centred on the Motor section, and the Cam and Good Shepherd claims are leased to the Giant company, a member of the same group. The nature of the ore is very variable, some of the gold being coarse and free, but the greater part associated with antimony and arsenic. Robert Allen was appointed manager a year ago, and he is devoting much attention to the metallurgical problem. The report for the year ended June 30 last shows that 149,639 tons of ore was treated, of which 11,457 tons was from the Cam and Good Shepherd claims. The yield of gold bullion was worth £201,618; in addition the gold content of slags was £4,687, and 9 tons of antimony sold for £175 gross, or £42 net. The financial result for the year was a loss of £11,753, without charging anything for depreciation. The ore reserve is estimated at 454,400 tons averaging 38s. 10d. per ton, no ore being included of less extractable value than 28s., the present cost of treatment. Owing to the slow settlement of the slime, it has been found necessary to enlarge the plant so as to bring the capacity to the required level. Preparations have been made for sinking the main shaft to the 9th and 10th levels, and it is proposed to carry on the work of sinking continuously until the development is once more well ahead of the requirements of the mill. It is hoped that the output will before long be 20,000 tons per month. The progress of effecting the improvements is much impeded by the limited supply of labour and by the scarcity of mining supplies of all sorts, but it is hoped that the alterations will be completed during the current year.

COMPANY MEETINGS and REPORTS SECTION

KYSHTIM CORPORATION, LIMITED.

Directors: C. J. Cater Scott (*Chairman*), Leslie Urquhart (*Managing Director*), R. Gilman Brown, T. Blair Reynolds, S. Polak, D. J. Morgan, A. J. H. Smith, Baron V. V. Meller-Zakomelsky. *Secretary:* J. P. B. Webster. *Office:* 7, Gracechurch Street, London, E.C. *Formed* 1908. *Capital:* £1,254,240 in £1 shares; debentures outstanding £13,300.

Business: Owns the entire share capital of the Kyshtim Mining Works, a Russian company operating copper mines and smelters in the Ural mountains.

The eighth ordinary annual general meeting of the shareholders of the Kyshtim Corporation, Ltd., was held on December 14 at Winchester House, Old Broad Street, London, E.C., Mr. C. J. Cater Scott (the Chairman) presiding.

The Secretary (Mr. J. P. B. Webster) having read the notice convening the meeting,

The Chairman said: I presume it will be your pleasure to take what we have submitted to you in the way of a report as read. It falls to my lot to meet you for the first time as Chairman of this corporation under conditions which, as you will readily understand, make for irregularity. The completion of our accounts for 1916 must await those of the Kyshtim Mining Works, which we have not yet received, and which are evidently very much in arrear. Our report is dependent on the accounts, so that the chief resolution to be submitted at this annual meeting has to be postponed. I propose to-day to take the other resolutions on the agenda—namely, for the re-election of directors and for the re-appointment of auditors—and then to move the adjournment. As, however, it is the wish of the board that you should be informed without delay as to the position of the Kyshtim Mining Works, so far as we are able to present it, and as to the affairs of this corporation, I will, on the motion for adjournment, make some remarks bearing on these matters. Now, to proceed with the course which I have outlined, I beg to propose:—"That Mr. A. J. Hugh Smith, Mr. Saveli Polak, and Mr. T. Blair Reynolds be re-elected directors of the company."

Mr. R. Gilman Brown: I beg to second that.

The resolution was carried unanimously.

The Chairman: The next resolution is the re-election of directors appointed and now retiring under article 105 of the articles of association, and I will ask Mr. Urquhart to propose this resolution.

Mr. Leslie Urquhart: I beg to propose:—"That Mr. C. J. Cater Scott, Mr. D. P. Mitchell, and Mr. David Morgan be re-elected directors of the company."

Mr. T. Blair Reynolds seconded the motion, which was unanimously agreed to.

Mr. F. Coad: I have great pleasure in proposing:—"That Messrs. Deloitte, Plender, Griffiths and Co. be reappointed auditors of the corporation for the ensuing year at a fee of 50 guineas."

Mr. H. E. Scarfe seconded the motion, which was passed unanimously.

The Chairman: In moving the adjournment of this meeting, I will first draw your attention to a few points in connection with the operations of the Kyshtim Mining Works for 1916, the year this meeting is called to consider. Although the full returns have not been received, there has been sufficient information in the hands of Mr. Gilman Brown, the consulting engineer of the Kyshtim Mining Works, to enable him to prepare his report, which is in your hands, and in which details of the year's work are set out. I notice that your late Chairman, rather over a year ago, gave forecasts of the blister output, average cost of copper, and average selling price. The output was somewhat below his anticipation—6,392 tons, against 6,600 tons—but it will probably be found, when the full returns come to hand, that the forecasts of Rs.10 a pood for the cost, and Rs.30 a pood for the average selling price of refined copper will prove very nearly correct. I am, fortunately, able to-day to give you more information with regard to the results of 1916. At the beginning of this week we received a telegram from Russia stating that the profits of the Kyshtim Mining Works for that year amount to over Rs.6,000,000, and that after making provision for depreciation, reserves, and taxes, the balance remaining at the disposal of the shareholders will be about Rs.2,500,000. We are not informed whether these are audited figures, and they cannot, therefore, be regarded as final, but they may be taken as a basis of comparison with the previous year, when the gross profit was Rs.4,400,000, and the divisible balance was Rs.1,470,000. For the rest, the technical report shows that in 1916 the work performed at the Soymanovsk Mines was, notwithstanding war conditions, on the whole satisfactory. But what of 1917? How has the Russian company fared during the period of industrial anarchy since March last? The outstanding feature is stated in the circular accompanying the notice of this meeting, namely, that no stoppage has taken place in the operations at Kyshtim. I will not enlarge on the enormous difficulties that have been faced and overcome by our colleagues on the board of the Russian company and by those loyal Russian administrators and employees who have assisted them. Some of these difficulties are known to this board, and we can assure you of their magnitude. I am sure it would be your desire that we should send a message to our Russian friends from the British shareholders gathered here to-day conveying the warmest and most friendly feelings of sympathy and gratitude. What will be the net effect of these abnormal conditions on the results for the current year it is impossible to say. On the one hand, we shall find costs largely increased by high wages and reduced efficiency, together with an increased head charge consequent on an output of copper diminished by about 1,000 tons. Against this will be set the very material rise in the price of copper in Russia, from about Rs.30 a pood at the beginning of the year to a fixed price of Rs.41 in April and Rs.48 since June. Whatever the result may be, I think we may congratulate ourselves on what has been accomplished, and on the fact that onr interests have not been further prejudiced.

In one department the progress has been remarkable, and the results no less so. You have doubtless noticed the paragraph in the technical report on the prospecting results. These form part of the admirable geological work performed in various parts of the estate. Four ore deposits are mentioned, two of which were referred to a year ago as promising prospects. The first, known as Kusnechinsky, has now been partially developed, with the result that we may look forward to the opening up of at least 150,000 tons of 2·8% copper ore—a valuable addition to our potential resources. But a discovery of even greater promise is that in the "No. 198 Quartel." Here a length of 2,400 ft. of ore has been opened up on the surface. The indications to be observed with regard to this deposit are the gold values in relation to the copper, which are considerably higher than in the working mines in the Soymanovsk Valley, and the presence in the deeper bore-holes of a commercially important percentage of zinc. When one considers that the length of this occurrence on the surface is about two and a-half times that of the Koniukhoff Mine, the importance of the discovery is apparent. At the "No. 15 Quartel" there are surface indications of an ore-body or bodies extending over no less than a mile in length. Where the deposit has been exposed small quantities of copper, gold, and silver are shown. Experience of the geology of the country enables the engineers to say that the conditions are favourable for the occurrence of copper ore in depth. You were informed a year ago of the discovery of nickel on the estates. Further development of these prospects indicates that they are important as the basis of new metallurgical industry. There are at present disclosed 40,000 tons of nickel ore, of sufficient grade to yield a substantial profit. In fact, I may tell you that a leading expert on nickel who has visited the district representing large producers of the metal in other countries, has suggested that they would be ready at any time to undertake the development and exploitation of these deposits. These discoveries, which have been made during the past twelve months under most disadvantageous conditions, present problems, metallurgical and financial, the solution of which must await more settled times. They give a clear indication, however, of very extensive additions to the mineral resources of the estates.

I will now turn to the financial position. In April last, soon after the Revolution, the board issued a circular informing you that the necessity of guarding against the uncertain future conditions by conserving as far as possible the financial resources of the Kyshtim Mining Works prevented that company from paying over to this corporation any part of the amount standing to its credit for the purpose of paying the dividend which had been foreshadowed a year ago. Events have shown the wisdom of this course. Since that time costs on all sides have risen greatly, so that the financing of stocks required much larger working capital. At the same time, largely increased outlay was required for the purchase of materials, the prices of all commodities having risen inordinately. We are without exact information with regard to the actual position, but taking all the known factors into consideration we have come to the conclusion that, so far as the interests of this corporation are concerned, we may regard the future from the financial point of view without anxiety.

My remarks, of necessity, have been rather general, but I think you will have gathered from them that our Russian friends have weathered the storm, and that there is nothing to prevent the resumption, under these settled conditions to which we cannot but look forward, of an adequate return from this pioneer of the Russian non-ferrous metal industry, on the large amount of British capital which has been invested in it.

The Chairman then dealt with the paragraph in the report which runs as follows :—"The urgent necessity for the adoption of prompt measures to uphold and safeguard British interests in Russian mining undertakings which British enterprise discovered and British capital has developed has been so forcibly impressed on your directors that they recently made arrangements which they believe will secure the object desired," and he described the nature of these arrangements. These particulars were given in the Chairman's speech at the Irtysh Corporation meeting reported in our December issue.

The Chairman proceeded : There is only one question on which I have not touched. It is that on which you probably would desire enlightenment more than on any other, namely, how are the vital interests of this company likely to be affected by the changes which have taken place, and are taking place in Russia? This is obviously a matter of opinion, and I am sure we all agree that no man is better qualified and able to form a just opinion than our friend the managing director, Mr. Leslie Urquhart. As many of you are doubtless aware, Mr. Urquhart was good enough last summer, in company with Mr. T. J. Jones, one of the consulting engineers of the Kyshtim Mining Works, to face the perils and discomforts of a journey to, and stay in, Petrograd, to look after the affairs of this and other companies in which he is interested. Any remarks that he might make would, I am sure, be listened to by you with the greatest interest, and I therefore ask him, in seconding the resolution which I am about to propose, to say a few words on the Russian situation.

Mr. Leslie Urquhart said : The speech of our Chairman, which you have just heard, is a conservative statement of the physical and financial position of the Russian company, but I think you will agree that in times like these it is better to err on the right side. The Soymanovsk Valley alone, in which all the mines at present in exploitation are placed, contains of itself reasonable expectations for the production of 10,000 to 12,000 tons of copper a year for probably the next 20 to 25 years, but thanks to the successful work of the Geological Department, since we met a year ago, a new mining district has been disclosed in the northern part of the estates, some 50 miles from Soymanovsk, which holds out great promise of turning out as important as the Soymanovsk Valley itself. Besides this, the possibilities of establishing an important mining industry by the development of the newly-found nickel deposits on the estates are very hopeful. The 40,000 tons of ore which have been developed are no criterion of the size of these deposits, which, judging from the large area mineralized, promise very important developments. The financial position of the Russian company is very healthy and sound. During the war the Russian Government made large advances to many persons and companies for the purpose of establishing new industries necessary for the production of materials for the war. As the financial position of the Kyshtim Mining Works was strong we only took advantage of the financial assistance of the Russian Government to a very small extent.

We considered it to be more conservative policy to enter into agreements with the Russian Government to undertake to establish certain works which the Government required for the production of special materials for the war at the Russian company's expense in consideration of the Government purchasing the full output of these works over a stated period at remunerative prices. Further, it has been agreed that the capital expenditure incurred can be written off out of profits to the extent of 50% per annum until these works are written off, these amounts not being subject to taxation. You will realize the importance of these arrangements when I inform you that the Russian company has erected dynamite or nitro-glycerine works on the most modern lines, with a capacity of 1,200 tons per annum; a sulphuric acid works, with a capacity of 8,000 tons per annum; nitric acid works for the purpose of serving all the requirements of the dynamite works, and, lastly, a sulphate of copper factory with a production at the rate of 4,000 tons of sulphate of copper per annum. The whole of these works have been so constructed that they can all be very easily extended and increased, and all of them have been in satisfactory operation for some time past and are earning good profits. While we were very anxious to help the Russian Government in any way we possibly could, we naturally had to look at the investment of very considerable sums of money in the development of new commercial undertakings on the estates from a purely business point of view. We had already taken and fulfilled large contracts for the production of aerial torpedoes and hand grenades, but the Kasli foundries were well equipped for this purpose, and it only required the addition of about 100 small lathes to our mechanical engineering works to handle a big output.

In deciding on the erection of large sulphuric acid, nitric acid, dynamite, and sulphate of copper works we kept in view that the principal basic material, sulphur pyrites, was present and was being mined on the estates in large quantities and very cheaply; in fact, most of the raw materials required were being produced at Kyshtim. The geographical position for the Urals and Siberia was excellent, and we are satisfied that the marketing of the products would be very profitable even after the war, apart altogether from the Kyshtim, Tanalyk, and Irtysh group of companies, whose increasing requirements in dynamite alone are at present over 400 tons per annum. Sulphate of copper was previously to a large extent imported from Germany, whereas we were in the country and produced the raw materials. It is evident, therefore, that if we have been unable, owing to the many reasons you know of, to distribute the profits earned by the Russian company, we have used these moneys to the best purpose possible in increasing the value of the properties by establishing important commercial enterprises on the estates, which are now, and will continue to be, a source of large and increasing revenue after the war. You will readily realize how strong the financial position of the Russian company is when I tell you that about 3,500,000 roubles of the cash expenditure in the establishment of these important new enterprises, costing in all some 5,000,000 roubles, has been provided by the Russian company out of its own resources without in any way decreasing either the working capital or the financial strength of the company. It was not deemed advisable at last year's meeting to give detailed information regarding these new works, as it might have been detrimental to the interests of the Allies; but since the Bolshevik Government has publicly made known secret contracts of honour, we considered this obligation no longer binding, and that it was time that our shareholders should be informed as to these new enterprises.

To those who read in the papers the news which comes from Petrograd, censored or doped by the usurping Bolshevik Government, the happenings in Russia may be the cause of considerable anxiety, but I would point out that Petrograd is not Russia, as the news coming through lately very clearly shows. The Soviets formed all over the country are to-day in control of the Bolsheviks, a curious jumble of sentimental idealists, extreme anarchists, and German emissaries, whose leaders have constituted themselves the Government at Petrograd to-day. These extremists and traitors obtained the support of the workmen of the towns and the soldiers at the Front by pandering to their lowest instincts by preaching class hatred and plunder and by peace fraternization propaganda among the ignorant soldiery, fostered by German money and alcohol. That they quickly demoralized by their teachings the workmen of the towns and the soldiery cannot be wondered at. The deciding factor in the crisis to-day is the question of food. It was a state bordering on famine which brought about the revolution, and the excesses which have been committed since by the workers of the towns and the licentious deserting soldiery have brought famine to the towns and made life unbearable under Bolshevik rule for everyone in the country. The reaction is now taking place; the people of the country are longing for law and order, and the time is very near when the strong hand of a military dictatorship will be welcomed as the salvation of the country. The trend in this direction is so clearly portrayed in the papers that I need not here emphasize my beliefs. The chaos and anarchy in Western European Russia, although we are some 1,300 miles away from Petrograd, has naturally affected to some extent the morale and discipline of our workmen, but this is mainly due to the anarchist agitators in the Soviets when they visit Kyshtim. During my stay in Petrograd I had many discussions with delegations of our men, but the questions at issue were mainly of an economic nature and depended on the relative cost of food to the value of wages paid. In this respect we are in a fortunate position. The Urals produce more food than that country can consume; the wheat which may be exported to Western Europe is easily replaced by the adjacent wheat-producing districts of Siberia. The management of the Russian company, therefore, realizing that the cost of food, clothing and boots was the main issue in the settlement of the economic problems, purchased ahead large quantities of food and other commodities at almost normal prices, and established a boot factory for the needs of the men and their families; and thus by supplying these requisites at cost prices wages have been kept within very reasonable limits. Any increases which have been made are more than covered by the higher prices received for the metals produced. The Russian Kyshtim Company employs directly and indirectly over 20,000 men, and with their families over 100,000 souls live on the Kyshtim estates directly dependent on the operations of the Kyshtim mining works.

The Russian company is a very old undertaking; the accounts and records in our possession go back for nearly 130 years, and the people, therefore, understand —indeed, with them it is almost a tradition—that the operations of the works are a necessity for their well-being. The relations between the management and the workpeople have in the past been of an intimate and most friendly nature. The terrible distrust and envy which is the gospel preached by the Bolshevik enemies of society has naturally affected the irresponsible spirits among the young workmen and those who have only lately come to the properties, but the great majority of the men, who were born and have lived with their families on the estates all their lives, are at heart a conservative and a moderating element. Thanks to them we have been able to continue work, and as the Chairmen has already said there has not been a single day's stoppage of work since the beginning of the Revolution. Naturally, during the terrible happenings in Russia the directors in Petrograd and the management at Kyshtim have gone through a most difficult time. It is greatly due to their tactfulness, loyalty and devotion to the interests of the company that we have such a reassuring statement to make to-day, and I feel that it is the duty —may I say the privilege?—of the shareholders to recognize by a vote of thanks the self-sacrificing efforts of our President, Baron Meller-Zakomelsky, and all our colleagues on the Russian Board, as well as the managers at Kyshtim and the loyal elements which work with them in the interests, not only of the company, but as a healthy example of sound common sense to the whole of Russia.

As to the question of how the vital interests—that is the ownership of our properties—are likely to be affected by the present happenings in Russia, I would say as definitely as I possibly can that the statements of the absurd Bolshevik usurpers as to repudiation of contracts should not be taken seriously; they are the ravings of crazy men. At the most the Bolsheviks represent not 10% of the country, mainly the industrial workers and the railwaymen. These people, however, are even now turning against there anarchist leaders, for Nature is forcing them by famine and suffering to see common sense. Eighty-five per cent. of the Russian people live on the land as peasant landowners or as peasant communities; only 10% of the whole represent large landed estates, while Siberia is entirely State-owned. Besides this, the Bashkir, Kirgiz, and Cossacks, who are a large element of the population, own their own lands. Are all these people going to give up their hereditary and private ownership rights in order to satisfy the socialistic ravings of madmen and the greed of the landless proletariat of the towns? We see to-day from what is happening in Russia that these men will fight to the death rather than accept the anarchist theories of the Bolsheviks. We are bound on the western part of our estates for a length of over eighty miles by the Bashkir community lands; less than thirty miles away we have the Cossack lands of Orenburg, and we see to-day that the Cossack general, Dutoff, has cleared out the Bolshevik Military Committee at Cheliabinsk near our boundary and disarmed and dispersed the Bolshevik soldiers there. Their influence is already beginning to be felt, and the Bolshevik Soviet Committees are daily losing their authority and their power for evil. As a matter of fact, the working people themselves at Kyshtim would protest at any attempt at expropriation, as already all the workpeople on the estates are granted by the company all the agricultural land, on a purely nominal rental, that they may wish to cultivate. An attempt was made during the summer by the peasants on the estates to prevent the company felling timber in the forests, but the workpeople quickly realized that if they prevented the Russian company doing so, as a result the works would be closed down and they would be out of work. Further, while their expropriation of the Kyshtim forests might bring the workers a total income of 600,000 or 700,000 roubles a year, they are receiving from the operations of the works some 6,000,000 to 7,000,000 roubles a year in wages.

In a word, Russia is industrially insufficiently developed; the land of the country is practically owned by the people or by the State. Therefore, Russia cannot with any common-sense reasoning be anything else but a respector of all property rights. I have a passionate certainty of conviction that all this chaos and anarchy is but the cleansing fire which will get rid of all that is rotten and make Russia purer and greater. 200,000,000 of people who have settled and themselves formed an empire of over 8,500,000 square miles are not destined to perish or disintegrate. The sufferings and miseries which she has gone through by following the teachings of sentimental anarchists, adventurers and traitors have given her people a lesson they will never forget, and I feel certain that there is a strong reaction to-day, in which in all probability the Cossacks will play, and are playing, a great part, which will bring back law and order in the land before very long.

The Chairman: Before moving the resolution for the adjournment I should like, in your name, to thank Mr. Urquhart for the very interesting statement he has made to us, which I am sure you will all appreciate. I now move: "That this meeting stand adjourned to a date of which due notice shall be given to the members of the corporation."

Mr. Urquhart seconded the motion, which was carried unanimously.

Mr Francis Moore: Before the meeting concludes I should like to say a word or two. I am sure you will support the directors entirely in the steps they have already adopted for safeguarding our interests, and endorse their action with acclamation. Our property is not merely a mining undertaking, which was certainly established 150 years ago, but it is now a great industrial concern, absolutely self-contained. We have now an important chemical industry established and producing profits, and we have had also foreshadowed two other new industries—the nickel and the zinc—which we never dreamt of before. I am sure we must congratulate the directors very heartily on their enterprise, and I hope we shall pass a vote of thanks to the Chairman and directors, and I wish specially to mention Baron Meller-Zakomelsky, who, together with our other Russian friends, has borne the heat and burden of the day during these terrible times in Russia. There is no doubt that he has carried on his work under most difficult conditions, and I hope you will support me when I say that we ought to accord him a special vote of thanks, as well as our other Russian friends, for the strenuous energy they have put into the work and for the ability with which they have conducted our affairs.

Mr. McLeod: I should like to second that resolution and, at the same time, to couple with it another two names—namely, Mr. Leslie Urquhart and Mr. Jones —because we must not forget that during the most trying period of the revolution Mr. Urquhart and Mr. Jones went out and stayed at Petrograd.

The motion was passed with acclamation, and the meeting then stood adjourned.

TANALYK CORPORATION, LIMITED.

Directors: Leslie Urquhart (*Chairman*), R. Gilman Brown, D. P. Mitchell, Baron V. V. Meller-Zakomelsky, T. Blair Reynolds, V. V. Romanoff, Major C. A. Reid-Scott. *London Manager and Secretary:* J. P. B. Webster. *Office:* 7, Gracechurch St., London, E.C.3. *Formed* 1912. *Capital issued:* £353,991 in shares of £1 each; debentures £198,357.

Business: Operates a group of copper-gold mines in the Urals, including the Mambet, Ulali, Tanalyk, Troitsk, and Tuba.

The fifth ordinary annual general meeting of the Tanalyk Corporation, Ltd., was held on December 14 at Winchester House, Old Broad Street, London, E.C., Mr. Leslie Urquhart (the Chairman) presiding.

The London Manager and Secretary (Mr. J. P. B. Webster) having read the notice convening the meeting and the report of the auditors,

The Chairman said: I presume it will be your pleasure to take as read the report and accounts which have been circulated among you. The corporation's accounts call for no comment from me, for they only cover the ordinary London expenditure and the charges to the Russian company in respect of loans, etc. The accounts of the Russian company show that in 1916 the trading profit amounted to about 700,000 roubles, practically the same as that for 1915, and although full details are not yet to hand to permit of consideration, the Russian company proposes to adopt the conservative policy of previous years in writing off depreciation at the highest rate permitted. But this figure of 700,000 roubles trading profit for last year is arrived at by including the stocks of metals at cost prices and not at sale prices. As you will readily understand, the stocks of metals on hand have increased partly owing to the abnormal conditions now prevailing in Russia, but to a great extent due to the larger scale of our gold mining operations. Were the stocks at the end of last year of gold, silver, and copper brought into the accounts at market value, or at prices at which they were subsequently realized, the profit shown would be very much greater than that forecasted by me at our last meeting. Thus, despite the difficult times through which we are passing in Russia, our profits for 1916 have far exceeded our forecasts. In the ordinary way such results would justify us in paying an initial dividend, but you know of the prohibition of remittances of money to this country and other reasons which prevent us from doing so. It is, perhaps, as well, in view of the political happenings and the satisfactory development of our properties, that the cash resources of the Russian company should be held for the present, not only to meet any unexpected situation which may arise, but also that we may quickly reap the benefit of the new developments at the mines when we return to more normal times.

You have all received a copy of Mr. Gilman Brown's report, and I will, therefore, only touch on a few salient points. From this you will see that the principal sources of ore have been the Mambet and Ulali mines for the sulphide ore, and the Semeonovsky and Tuba for oxidized gold ore, the latter assaying over 3½ oz. gold and 23 oz. silver per ton. It is very gratifying to note that sulphide ore has been cut on the second level of the Tuba mine, and that 175 ft. of this has been already proved over 8 ft. wide and assaying 17% copper and nearly one-fifth of an ounce gold per ton. The development that has been effected at the Sebaeva has turned this prospect into a mine with nearly half a million tons of pyrite ore proved to date, and vast possibilities for extensions in length and depth. This is a discovery of the first importance; the character and grade of the ore make it highly suitable for cheap mining and smelting, and the quantity here already exposed is far in excess of anything that any one of the other mines has furnished. In the all-important matter of ore reserves the position is very strong; the small decrease in tonnage of oxidized ore in comparison with last year is more than made up by the increase in gold contents, and the sulphide ore shows an increased tonnage of from four to five times that reported at our last year's meeting, and with over three times the gross copper contents. It will be seen, therefore, that notwithstanding the difficulties caused by the war and the chaos in the country since the revolution, the Russian company has not only been able to continue mining and smelting operations at the previous rate, but that the ore reserves are now nearly 500,000 tons more than when I last had the pleasure of addressing you. Not only this, but we have tackled during this year the question of fuel supply, on which depends the further increase of our metals production, by surveying and starting the earth work and grading of a light railway 40 miles long to the forest concession. A great deal of work has already been done; the major part of the rails necessary have already been delivered at the property, and it is probable that when we meet again next year this railway will be completed. I am glad to say that the cost of the railway, which is estimated at Rs. 700,000, will be entirely and easily defrayed out of revenue. It is evident, therefore, that if the Russian company is unable to pay you the profits which have been earned in Russia, it is fortunately able to utilize these profits by increasing the value of the properties, making ready for the day when the war is over, and when stable government is established in Russia, to reap the full advantage of the longer life and greater earning capacity of the enterprise.

That we have been able to carry on so well when Russia is in a state of chaotic flux has been mainly due to our being far away from the centres of unrest and anarchy, about 1,500 miles from Petrograd, and to the fact that we are in a district where food is abundant, and in the country of the Bashkirs and Orenburg Cossacks. As you know, the Tanalyk mining properties have been granted to us on a long lease on a royalty basis by the Bashkir Mussulman peasant communities of the Bourzian Estates. The lease was duly confirmed by the late Russian Government. The Bashkirs, being far away from industrial centres, were dependent on produce raised by themselves, and lived a very hard existence. Only on the advent and development of our enterprise at Tanalyk did they feel for the first time some material prosperity. The royalty the Russian company pays brings in a comfortable revenue to the communities, which goes to the payment of their taxes; the enterprise gives employment to some 2,000 Bashkirs. In a word, the money daily expended at Tanalyk has materially raised the prosperity of these communities, whose workers previously had to go hundreds of miles from home to obtain work. The Bashkirs are not liable to military service; they do not speak Russian, their language being akin to Tartar, and they have, therefore, not been tainted by the extreme socialistic ideas that the simple ignorant Russian proletariat, thanks to the teachings and promises of demagogues and traitors, has imbibed so readily. There are some 200 to 300 Russians employed at Tanalyk, but this is an immigrating population, who do not speak Bashkir, and have no influence over the Bashkir population. I do not pretend that there have been no labour troubles at Tanalyk; this would be unfair appreciation of the patience and tact, under most difficult conditions, of our managing director, M. Kabanoff, the management, and the loyal Russian employees, who have gone through, and are going through, a time of great stress and strain. It is mainly due to the courageous and patient handling by M. Kabanoff, and the men working under him, of all the difficult problems raised by the Russian workers that mining and smelting operations have continued almost normally, and that such splendid work has been done in the further development of the mineral resources of the estate, and I feel sure that the shareholders will wish to voice their appreciation of the loyal devotion to their interests.

The great majority of even the Russian workmen employed are moderate and law-abiding in their views, and recognize that the excesses of the proletariat in European Russia have done the workers no good; on the contrary, it is being pressed home to them by the very direct evidence brought by workmen who have suffered from such excesses that they are comparatively very well off at Tanalyk, that they have not only work but food. The labour troubles which the management have had to meet at Tanalyk have been mainly of an economic nature. The internal value of the rouble has fallen owing to the excessive demands of the workmen in European Russia and the disorganization of the machinery of State. But the value of the rouble to-day and the wages paid are entirely dependent on the price of food. Wheat, meat, butter, eggs, and milk are fairly plentiful in the Orenburg Government. The Russian company, by purchasing large quantities ahead, can do so at comparatively low prices, and by selling from its own stores at cost price to the workmen keeps down the price of essential food commodities. By this common-sense policy wages have been kept within very reasonable limits, and the increases made are well covered by the high prices received for the copper, gold, and silver produced and leave a very good profit. Left to themselves even the Russian workmen cause no trouble. It is only when anarchist agitator members of the Ekaterinburg Soviet of Workmen's and Soldiers' delegates, subordinate to the Central Soviet at Petrograd, come to the property that dissatisfaction among the Russian workmen is stirred up and absurdly excessive demands are made. The influence of the Bashkir, who are five times the number of Russian employees, and who are virtually our partners as royalty owners, and who recognize that the stopping of the properties will cause them not only loss of revenue at home, but also of food, has always been sufficient to prevent any excesses. The Bashkir refuse to participate in any of the movements of the Russian workmen when the Soviet delegates arrive. In fact, the very thought of what might happen to their well being should we be forced to shut down makes their attitude very firm and even aggressive. Further than this, they openly threaten to drive out the Russian workmen should they make the slightest attempt to obstruct or stop the working of the properties.

As an instance of the evil influence of the Soviets in deliberately fomenting agitation among the working classes, the following may be of interest. During a period of quiet and productive work, a telegram was received some six weeks ago by the local Committee of Workmen at Tanalyk from the Ekaterinburg Soviet, informing them that a resolution had been passed by the Soviets to expropriate our properties and demanding that horses and a carriage should be sent to a railway station 250 miles away to meet two of the Soviet delegates and bring them to Tanalyk. The manager, knowing that the arrival of these demagogue anarchists would be the cause of excitement and would agitate the workmen, refused to supply the horses. The unruly element among the Russian workmen then commandeered one of the company's motor cars. The manager immediately wired the managing director, who was then on his way to the property, of what had taken place. I would mention that a short time before this event an alliance had been entered into between Bashkir communities and the Cossacks of the Orenburg Government mutually to protect their property rights from any attempts at expropriation. The Cossacks and Bashkir represent over 60% of the population of the Orenburg Government, and own large tracts of land in absolute right, the remainder being owned by the State or community lands cultivated by Russian peasants. On receipt of the telegram M. Kabanoff called immediately on General Dutoff, the Ataman, or chief, of the Cossacks of the Orenburg Government, and laid his case before him. General Dutoff immediately gave orders in M. Kabanoff's presence, and sent 50 armed Cossacks to Tanalyk. On their arrival the few bold spirits among the workmen were cowed, while the delegates of the Soviet were frightened at their own audacity, and disappeared hot-foot off the property, but this time by their own exertions and without the aid of the company's motor-car. Work continued and continues normally, and I believe, apart altogether from the Bashkir, who have always to their credit been orderly, that the great majority of the Russian workmen are more than pleased at the presence of authority to keep the unruly among them in good order. I think, gentlemen, it will be evident that under the circumstances I have described we need have no fear about the continued operation of our properties, nor need we be afraid of excesses or attempts at temporary expropriation, for we have partners and powerful neighbours, whose interest it is just as much as it is ours to see that the natural laws of the inviolability of the person and property are absolutely respected.

So far as the usurping Bolshevik or Anarchist Government is concerned, the wild ravings of frenzied anarchists and traitors like Lenin, Trotsky, and their kind regarding expropriation and repudiation of contracts need not be taken seriously. The real Russia will never repudiate her contracts. History has never yet given as a precedent where a great nation has suddenly turned itself into a robber State. The most uncivilized savages recognize that to live as a community of human beings it is necessary to respect the sacred rights of the person and of private property. The denial of this elementary principle to the Russian people is equivalent to placing them outside the pale of humanity. As a matter of common sense it is unreasonable to believe that Russia, a nation of nearly 200,000,000 of people, the great majority of whom are ignorant and illiterate, are sufficiently developed for independent political life or a socialist government, having for its object the realization of extreme socialistic and anarchist theories. Eighty-five per cent of the population in European Russia live on the land, 10% only are large landed proprietors, the remainder are peasant or community land-owners, owning their own houses, cattle, stock, and food. They have a stake in the country to lose. Are they going to agree to divide up their property with the proletariat of the towns, who are the dupes of the present Bolshevik movement and only represent 10% of the population of the country? The action of the Orenburg Cossacks and Bashkir is indicative of the measure of success that the socialist and anarchist theories of the Bolsheviks can have in Russia when the peasant, the real Russia, understands the issues that are at stake. It is that very ignorance of the vast majority of the Russian people which makes socialist government impossible, that childishly trusting simplicity which has made them the dupes of the sentimental anarchists, traitors, and German emissaries who are in power to-day through the Soviets. They have had nine months of socialist and anarchist government, and they find to-day the army demoralized, the machinery of State and the railways broken down, the workers of the towns without work and without food, famine and misery staring them in the face; they have had enough of socialism and anarchy and all they stand for.

There are significant signs that the real Russia, which has a plentiful supply of foodstuffs, where there is comparative law and order, the Ukraine, the Don Cossacks, the Caucasus, the Urals and Siberia, of which we hear little or nothing, is preparing for that return to common sense and reason which is near at hand. The last election returns from the provinces for the Constituent Assembly clearly show this. In all some 2,700,000 votes have been cast for the Bolsheviks, while the Cadets, or bourgeois class, and the Revolutionary Socialists have each over 2,200,000 votes. These two parties are against a German peace and against the Bolsheviks; they score together about 4,500,000 votes. The Bolsheviks may make strenuous efforts to avert their disaster, but the day of retribution for the unscrupulous men who have sold Russia's honour inevitably draws on. To many of us the temporary defection of the Russian people from the Allied cause may bring bitter thoughts. They have temporarily lost their ideals of nationhood, led astray by the teachings of traitors and fools. But let us try and understand aud continue to sympathize, and, above all, let us have firm faith that the Russian people will soon reassert themselves and establish law and order in their land; they may yet be of real help to us before this war is over. In any case, the future of Russia is secure, and when she comes back to reason—and there are signs that the time is very near at hand—the generous-hearted Russian people will never forget that we were always her fast friends in the days of her great trouble.

The Chairman then proceeded to describe the proposed arrangement whereby the control of the company would be safe-guarded against any possible attempt on the part of enemy aliens securing it. These particulars were given in the Chairman's speech at the Irtysh Corporation meeting reported in our December issue. He concluded by moving that the directors' report, balance sheet, and statement of accounts for the year ended January 13, 1917, be received and adopted.

Mr. T. Blair Reynolds: I beg to second that.

Mr. Francis Moore: As nobody seems inclined to get up and say anything, I should like to say a word or two. In the course of his speech the Chairman has mentioned that we have been trusting those whom we have trusted in the past. Well, gentlemen, let us continue to trust those whom we have trusted in the past, because they have proved themselves worthy of our trust. I am sure you will unanimously support the measures which the directors have adopted to safeguard our interests against any possibility of an insidious campaign carried on by any hostile agency or enemy.

Mr. F. Coad: Mr. Chairman, I should like to ask you a question. At the meeting of the Irtysh Corporation you were good enough to say that the ore reserves now showed a profit value of about £13,000,000. Having regard to the fact that you are unable to give us the working costs on the Tanalyk, I was wondering whether you can tell us what is the estimated profit of the ore reserves in sight in the Tanalyk down to the end of June last.

The Chairman: With reference to Mr. Coad's question as to the value of the ore reserves and profits in sight, I am sorry that we have not got a detailed estimate as to those at the present moment, because the developments at the mines are, as you can gather from what I have already said, increasing at such a rapid rate that they are getting too far ahead of us, but I think it would be a conservative statement if I said that at pre-war prices for metals we certainly have £2,500,000 profit in sight.

Mr. Willis: In your remarks you referred to making arrangements for fuel. I take it that that fuel is chiefly obtained from your wood forests. Perhaps you can tell us whether you have any chance of finding another coal mine. I think I understood last year that you had some difficulty in getting fuel.

The Chairman: Since the meeting last year the Orsk Railway has been completed, and the distance from the property is only about 80 miles. We can obtain all the coke we require for our blast-furnaces at a comparatively cheap price. Previously it was much more expensive, as we had to carry it 250 miles. As to the railway to the forest, most of our work is done with wood fuel; our open-hearth furnaces are operated with wood fuel, and we have a very large concession — about 300,000 acres—for a long period, and we get all the timber necessary for our fuel requirements from there.

The resolution was then put to the meeting and carrid unanimously.

The Chairman: The next business of the meeting is the election of directors. I beg to move: "That Baron V. V. Meller-Zakomelsky, Messrs. D. P. Mitchell, and Herbert Gibson be elected directors of the Corporation."

Mr. R. Gilman Brown: I beg to second that.

The resolution was unanimously agreed to.

Mr. H. E. Scarfe: I beg to propose: "That Messrs. Deloitte, Plender, Griffiths and Co. be reappointed auditors of the Corporation for the ensuing year at a fee of 30 guineas."

Mr. Coad seconded the motion, which was passed unanimously.

Mr. Francis Moore: Gentlemen, I do not think we ought to separate without passing a hearty vote of thanks to the Chairman and directors. At the same time I should like to join the name of M. Kabanoff, the manager of our property. I happen to know M. Kabanoff personally. He is a man of unbounded energy, determination, and character, and I am sure that, in view of the trying times through which he has passed, you will appreciate what he has done in our interests.

The vote was unanimously accorded.

ANGLO-PERSIAN OIL COMPANY, LTD.

Directors: Charles Greenway (*Chairman and Managing Director*), Admiral Sir E. J. W. Slade (*Vice-Chairman*), Sir Hugh S. Barnes, J. T. Cargill, Sir Campbell K. Finlay, D. Garrow, James Hamilton, F. W. Lund, H. E. Nichols, F. C. Tiarks, Sir T. R. Wynne, Lord Inchcape (*appointed by His Majesty's Government*). *Secretary:* F. Macindoe. *Office:* 23, Great Winchester Street, London, E.C.2. *Formed* 1909. *Capital* issued at March 31, 1917: £1,000,000 preference shares, and £1,000,000 ordinary shares, both fully paid; 2,000,000 ordinary shares 12s. 6d. paid; debentures £600,000.
Business: Works petroleum deposits in Persia.

The eighth ordinary general meeting of the Anglo-Persian Oil Company, Ltd., was held on December 3 at the office of the company, Britannic House, 23, Great Winchester Street, London, E.C., Mr. Charles Greenway (Chairman and Managing Director) presiding.

The Chairman, in moving the adoption of the report and accounts, said that the paid up capital stood at £3,250,000, being an increase of £250,000 upon the figure of the previous year, due to the payment by His Majesty's Government of a further call. This payment brought the total amount of capital provided by the Government up to £1,251,000, leaving a balance of £949,000 still due at the end of the financial year out of the £2,200,000 which they undertook to provide by the agreement of 1914. They had issued a further £1,400,000 of debenture stock, bringing the total debenture issue at date up to £2,000,000. Including the debentures, the total capital now issued amounted to £6,000,000. The trading profit for the year amounted to £415,827 as against £171,723 in the previous year, which fully confirmed the anticipations expressed when he last had the pleasure of addressing shareholders. The current year was now sufficiently advanced for it to be possible to state that the trading profit shown in the next accounts would not be less than £800,000, and probably be nearer £1,000,000. As regards excess profits duty, the company, in common with all concerns which were in process of development on the outbreak of war, was in the unfortunate position of having a very low pre-war standard of profits. They had therefore claimed to be assessed on a capital percentage basis and this had been fixed at 11% in addition to which they would get the allowance of 3% on new capital put into the business since the beginning of the war.

The Government of India, after a long series of experiments and trial runs, which had amply demonstrated the greater efficiency and economy of oil, had recently decided to substitute to a large extent oil for coal on the Western Indian Railways. This substitution would not only be of financial advantage to the railways, but it would also effect a considerable economy in tonnage, inasmuch as the time occupied in carrying coal from Bengal to the West Coast of India was about thirty days for the round voyage, as against only fifteen days for the round voyage of oil from the Persian Gulf, while oil as a fuel for locomotives had roughly twice the efficiency of coal. In other words, to carry the fuel equivalent of 1,200,000 tons of coal, oil would only occupy space to the extent of 300,000 tons. A similar substitution would be carried out shortly on the Mesopotamian railways, whereby a further large economy of tonnage would be effected. The contracts which they had secured for fuel oil and other products now amounted to a total of no less than 12,000,000 to 15,000,000 tons. The extent to which the company had been able to assist the Navy by deliveries of fuel oil, could not be announced without committing a serious breach of the provisions of the Defence of the Realm Act, and divulgence of this information must therefore be withheld until the conclusion of the war.

An important development had recently taken place in the purchase of the shares of the German companies known as the British Petroleum Company, Ltd., the Homelight Oil Company, Ltd., and the Petroleum Steamship Company, Ltd. The two former were distributing companies, and their organizations would later on, when the Anglo-Persian Co's present arrangements for the sale of benzine and kerosene came to an end, doubtless prove a most valuable acquisition, as they would provide a means of disposing of their output at much better prices than was being realized at present. The company's production of benzine was now at the rate of about 150,000 tons per annum, and would by the time their extensions were completed, probably amount to 600,000 to 700.000 tons per annum. This might appear to be a very large figure compared with the United Kingdom's pre-war trade of less than 400,000 tons per annum, but with the very large increase in motor transport of all kinds which would certainly take place in this country and in Europe generally after the conclusion of the war, and with the entirely new demand which would have been created by the great development in aviation, he had not the slightest doubt that there would then be an offtake for all the benzine and all the benzol which the world would be able to produce.

The purchase of the shares in the Petroleum Steamship Company, Ltd., had given an addition of nine tankers to the fleet, which now numbered 22 vessels of a deadweight capacity of 130,915 tons. In addition to these they were managing nine other tankers of a deadweight capacity of 74,500 tons. This fleet, though large, would not nearly suffice for their future requirements and would need to be augmented considerably whenever it might be practicable to purchase or build additional tonnage. The new 10 inch pipeline was completed in January last and had since been working very satisfactorily. The refinery extensions referred to last year had not yet been completed owing to the loss at sea of some of the plant and to the delay under present conditions in replacing it, but they hoped to get them in operation in the course of a few months. Further large extensions required to be taken in hand immediately to meet urgent war requirements. The plant for these had already to a large extent been ordered, and to meet the additional capital outlay which would be incurred on them it was proposed to make an issue of a further 1,000,000 participating preference shares. These shares, which would rank for dividend as from October 1 last, would be issued at a premium.

Lord Inchcape seconded the resolution and it was carried unanimously.

The Chairman then moved the declaration of dividends; that an additional dividend of 2% on the preference shares, making 8% for the year, be paid in respect of the year ended March 31, 1917, and that a dividend of 6% per annum on the ordinary shares in respect of the same year be paid on the same date.

Mr. John T. Cargill seconded the resolution which was unanimously agreed to.

TRINIDAD LEASEHOLDS, LIMITED.

Directors: T. J. Milner (*Chairman*), A. W. Rogers (*Managing Director*), Major H. L. Sapte alternate J. C. Prinsep, R. H. McCarthy, J. L. Siddall. *Secretaries:* Central Mining & Investment Corporation, Ltd. *Office:* 1, London Wall Buildings, London, E.C. *Formed* 1913. *Capital:* £417,500; loan account £200,000. *Business:* Operates petroleum wells in the island of Trinidad.

The fourth ordinary general meeting of Trinidad Leaseholds, Ltd., was held on December 21 at the registered offices of the company, No. 1, London Wall Buildings, London, E.C., Mr. T. J. Milner (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts, said that for the first time they were presenting a profit and loss account. On the credit side the first item was the balance of production and refinery accounts, amounting to £106,403. This sum represented the balance of revenue from the sale of the various products and those purchased from the Trinidad Oil and Transport Company, Ltd., after charging royalties and wayleaves payable to the Trinidad Government, cost of operating the wells, and handling production. On the debit side administration and general expenses in Trinidad and London, directors' fees, secretarial remuneration for the year, and depreciation on wells, machinery, plant, etc., amounted to £52,542. Interest on advances accounted for £10,800 and the balance of profit for the year was £43,047. To it was added £35,091, being the balance of production and refinery accounts at June 30, 1916. Administration and general expenses, directors' fees, etc., and depreciation on wells, plant, and machinery up to June 30, 1916, amounted to £49,279. The whole of the preliminary expenses had been written off. The final balance of profit carried to the balance sheet amounted to £22,496. Depreciation on wells accounted for a large proportion of the amounts written off, and included the cost of four wells which had to be abandoned. In regard to the excess profits tax, in conjunction with other Trinidad oil companies they were taking up this question with the authorities and should be able to present a strong case for an increase in the statutory percentage allowance. They contended that oil mining as an industry, especially in Trinidad, could not be judged by ordinary standards, and was entitled to exceptional treatment. Owing to the fact that their company had not made profits in previous years, a very substantial amount would rank for deduction from any future excess profits that might become payable.

With their published statement of the March output they added a note to the effect that active steps were being taken to increase the production. Notwithstanding the delays inevitable under present conditions, and to the phenomenally heavy rains experienced in July, they had made very satisfactory progress, as their monthly returns had shown. For the year ended June last they produced 56,200 tons, as compared with 17,200 tons for the previous year, while for the last six months the average monthly output was approximately 10,600 tons. They had now 15 producing wells, compared with 12 at the date of the last annual meeting, and a further well had come in as a producer since the directors' report was issued. The extended programme of development was not quite completed, and they hoped in the next few months to increase still further the level of production now attained. They had on the Forest Reserve a proved field capable of carrying a considerable number of wells. New wells would therefore be sunk regularly to maintain the output as the production from the older wells decreased. The topping plant at La Carrière was brought into commission in May this year, and it was working most satisfactorily, producing fuel oil of excellent quality. The capacity was between 300 and 350 tons per day. The fractionating plant for separating the distillate tops into petrol and white oil was also giving good results. They had approximately 28,000 tons of closed tankage at the port; some further small tanks were now in course of construction, and others were on order. In a very short time the closed storage capacity at the port and elsewhere would approximate 50,000 tons.

The arrangement they entered into with the Trinidad Oil and Transport Company at the end of last year had been of mutual benefit. They had bought a large proportion of their output, taking delivery through a short branch pipeline which they laid down between their own trunk line and the Transport Company's wells. The board, being persuaded that the absorption of this company's property would be advantageous, opened negotiations some months ago, and a provisional agreement had now been entered into for the acquisition of that undertaking as at January 1 next. The issued share capital of the company was £159,224. Their property consisted of about 1,000 acres at Barrackpore and had been worked in a small way for about six years, during which period a local trade had been built up in fuel oil and petrol. Development had lately been pushed and the production of crude was now in the neighbourhood of 3,000 tons per month. There was every prospect of increasing the output in time. The company possessed a topping plant of a capacity of about 130 tons per day. The field was well equipped, and the present net annual revenue was about £40,000. They had provisionally agreed to pay 112,000 fully-paid shares for the property. After the formal business had been dealt with he would submit a resolution for increasing the nominal capital of the company from £550,000 to £850,000 by the creation of 300,000 new shares.

	Shares
The issued capital was today	417,500
The liquidation of the debt would absorb	170,000
The Trinidad Oil and Transport Company, Limited, received for their undertaking	112,000
The Treasury had been asked to sanction both these issues.	
Leaving in reserve for the future needs of the company	150,500
Total	850,000

In spite of the anxious times they had had in the past it was no small source of gratification to the directors that the year under review had brought the company to the profit-earning stage. They had again passed through a period of heavy expenditure on capital account, but they hoped that a large portion of the profits from the beginning of 1918 would be available for dividend purposes. They were now the largest producers of oil in the island of Trinidad.

Major H. L. Sapte seconded the resolution, which was carried unanimously.

CHAMPION REEF GOLD MINING CO. OF INDIA, LTD.

Directors : John Taylor *(Chairman)*, Lord Ribblesdale *(Vice-Chairman)*, Lord Glenconner, Sir John F. F. Horner, Sir J. D. Rees, Edgar Taylor. *Managers :* John Taylor & Sons. *Secretary :* F. H. Williams. *Office :* 6, Queen Street Place, London, E.C.4. *Formed* 1889. *Capital :* £260,000 in half-crown shares.

Business : Operates the Champion Reef gold mine in the Kolar district, Mysore State, South India.

The twenty-ninth ordinary general meeting of the Champion Reef Gold Mining Company of India, Ltd., was held on December 31, at the Cannon Street Hotel, London, E.C., Sir J. D. Rees, K.C.I.E., C.V.O., M.P., presiding.

The Chairman, in moving the adoption of the report and accounts, said that the financial results of the year could not be considered other than satisfactory. A comparison of the present with the previous balance sheet showed that the financial position had not only been maintained, but strengthened. The figure of £435,111 for sales of gold showed a decrease of £62,218, and the total revenue, amounting to £422,710, showed a net decrease of £55,379. Working expenses amounted to £267,136, a figure which exhibited the substantial reduction of £38,552. It was indicated in the last annual report that, pending improvements in the mine, it would be advisable to reduce the output, and as a result of that policy, the quantities of ore and tailing treated showed a considerable decrease. The loss of revenue had, however, been counterbalanced to a large extent by the reduction in working costs, by the higher yield from the ore, and by the more complete extraction obtained, consequent upon the addition of another tube-mill and to the improvement in the classification plant. After treatment by the cyanide department, the minute quantity of only 10 grains of gold per ton was left in the final residue. The prices of all materials used on the mine continued to advance, and were now enormously in excess of pre-war quotations. The profit on the year's working was £155,573, a decrease of £16,827 compared with the figure of the preceding twelve months. The balance of profit admitted of a final dividend for the year of 6d., making with the two interim dividends of 3d. each 1s. per share, the same total as that of last year. Mr. Gifford, in his report, while forecasting the probability of some further reduction in the output in the immediate future (should not more favourable developments soon appear), pointed out that there were indications of new ore-shoots in the deeper sections of the mine. Mr. Gifford was shortly resigning the position of superintendent, which he had held for twelve years, but he would not leave until his successor, who was now with the Ministry of Munitions, had arrived at the mine. He had been for 32 years in the service of John Taylor & Sons.

Sir John F. F. Horner, K.C.V.O., seconded the motion.

Mr. Edgar Taylor then proceeded to give details of the mining operations. He said there were indications of new ore-shoots forming in the deeper sections of the mine. The policy of deepening the mine as rapidly as possible, by the sinking of secondary shafts in proximity to the reef, had been continued during the year under review. Shaft sinking at Garland's, Glen, and Carmichael's had aggregated 1,222 ft., or 385 ft. more than in the previous year. In other respects there had been somewhat less development work done, the total amounting to 10,166 ft., as compared with 12,306 ft. Most of the deeper workings had continued in unproductive reef, and consequently, as a measure of economy, levels had been driven in certain sections at intervals of 200 or 300 ft. in depth, instead of at every 100 ft. as had hitherto been the practice in more productive zones. In Carmichael's section new levels had been started at the 55th and 53rd horizons, and recently a cross-cut had been driven to the reef west of the shaft at the 56th level. All these workings had been on poor reef. At the 51st level south of this shaft they had, however, met with encouragement, as the continued driving of this level, which had now communicated with the Glen section of the mine, passed through ore for a distance of 190 ft., the reef over this length averaging 17 dwt. for the width of 2 ft., and a winze sunk on this new shoot for a depth of 115 ft. disclosed ore assaying 1 oz. 11 dwt., the quartz here being 6 in. in width. It was expected that before long the 53rd level south would find the continuation of this ore in depth, and as the winze was on the northern extremity of the shoot, an increase in width might quite possibly occur. This shoot of ore was about midway between Carmichael's and Glen shafts, and was directly below the low-grade zone met with at the 49th level. To the south of Glen shaft, the ore-shoot referred to last year had held down regularly, with an average length of about 200 ft., to the 54th level, and at this level the quartz was still of good width and value. In this section of the mine the amount of ore developed between the 51st and 54th levels was fully equal to the amount stoped, and the decrease of 24,736 tons in the ore reserves, which now stood at 351,255 tons, was due to the absence of profitable developments elsewhere. In the southern section of the mine, at Garland's shaft, they had opened up a great quantity of quartz by means of the two deep winzes below the 48th down to the 51st level on the new shoot, which was dipping into the property and lengthening northward in depth. The whole of this had, however, unfortunately, proved that the ore, although up to 4 ft. and even 10 ft. in width, was too poor to be included in the reserves. Even here, nevertheless, they had some ground for encouragement, seeing that recently at the 51st level the eastern branch had been found to be payable, assaying 8 dwt. per ton over a width of 1½ ft. Compared with the previous year, the output of ore was 149,612 tons—or 44,699 tons less—and there was naturally from this cause alone an increase in the working cost per ton. This was, however, compensated for to a certain extent by the higher grade of the ore won and also by the higher rate of extraction of the gold contents, following on the improved methods now adopted in the treatment of the ore. With regard to constructional work, the extension of three mills to the tube-mill was nearly completed. The extension of the slime plant was already completed and in operation. The additional and reorganized concentrating plant had also been completed and was ready for work, and it would be seen that they were now benefiting by the expenditure of recent years upon the improvements to the reduction works.

The resolution was put to the meeting and unanimously adopted.

NORTHERN NIGERIA (BAUCHI) TIN MINES, LIMITED.

Directors: Hetherington White (*Chairman*), H. C. Godfray, G. Temple Harris, Oliver Wethered. *Secretary:* E. Price, *Office:* 19, St. Swithin's Lane, London, E.C.4. *Formed* 1910. *Capital issued:* £97,226 in ordinary shares and £126,281 in preference shares, both of 10s. each.
Business: Operates alluvial tin properties at N'Gel, near Naraguta, Northern Nigeria.

The ordinary general meeting of the Northern Nigeria (Bauchi) Tin Mines, Ltd., was held on December 19 at the London Chamber of Commerce, Oxford Court, London, E.C., Mr. Hetherington White (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts, said he would like to say a few words to express their regret at the resignation of their late Chairman, Sir Robert Hampson. Owing to continued ill-health he was unable to attend any meetings this year, and finally tendered his resignation in the autumn. The issued capital remained the same as last year, namely, £223,508, divided into 194,453 ordinary shares and 252,563 preference shares of 10s. each. Creditors and credit balances showed a total of £8,114, of which £4,867 represented freight charges and royalty on tin. Practically the whole of the £8,114 had been settled since the date of the accounts. They had spent on property account £659 for survey and other expenses in taking up mining leases. The expenditure on development and prospecting for the year amounted to £4,064, and they had written off on the recommendation of the manager £1,138, leaving on this account £19,747 against £16,821 at June 30, 1916. Against this difference they had increased the reserve of tin from 3,340 tons to 6,876 tons. The expenditure on buildings, machinery, and plant was £2,378, and they had written off £4,364, leaving this item at £17,800. The tools and stores had been taken in at valuation, namely, £5,297. Shares and debentures in other companies had been reduced from £20,935 to £7,534. Debtors and debit balances amounted to £20,245, of which £17,300 represented the value of tin sold at the date of the accounts and paid for since. The tin in stock, namely, £25,562, had been taken at the price which it had since realized. Taking the tin sold and the tin in stock at the date of the accounts at the realized figure, the price worked out at an average of £152. 5s. 9d. per ton. The expenses, calculated on the tonnage recovered—namely, 555 tons for the 12 months—worked out as follows: Mining expenses, £58. 15s. 9d. per ton, against £55. 5s. 5d. last year; freight and other charges on tin, £23. 2s. per ton, against £18. 2s. 8d. last year; royalty, £10. 13s. 3d. per ton, against £7. 1s. 1d. last year; and sundry expenses in London, £4. 3s. 11d., of which £2. 12s. 6d. was covered by sundry receipts. The details of the London expenditure were as follows: Audit fee, £52 10s.; cablegrams and postages, £153. 16s. 4d.; consulting engineer's fee, £262. 10s.; directors' fees, £631. 12s. 11d.; general expenses, £161. 0s. 11d.; legal expenses, £11. 8s. 6d.: rent of offices and services of staff, £251. 19s. 6d.; stationery and printing, £180. 0s. 7d.; transfer fees, etc.; £24. 14s. The depreciation written off buildings, plant, and machinery—namely, £4,364—previously referred to, and the amount written off development and prospecting expenses, £1,138, amounted together to £9. 18s. 3d. per ton, making the all-in costs £106. 12s. 3d. per ton, leaving a profit of £48. 5s. 1d. per ton.

With regard to the investments, at the last meeting he said it was quite understood by the directors that the shareholders desired them to realize the investments as occasions served, and the attention of the board was to be entirely devoted to the development of their own property. Acting on this, the directors had realized most of the shares in other companies as opportunity offered, and at the best possible price obtainable at the time of sale. Since June 30, 1916, they had sold shares for £13,401, leaving on the investment account £7,534. They expected to realize the balance shortly at not less than the figure at which they stood in the books.

Concerning the prospects and development of the property, last year they had 3,340 tons of tin proved, and this year they had increased this to more than double the quantity, namely, 6,876 tons. It was not to be expected they would continue to develop at anything like this rate, but he had no doubt they would add considerable quantities to their reserve year by year. In addition to the increase of reserves, they had obtained a means of working them in an economical manner by power obtained from the Kwall Falls. Regarding this Government concession, they had already taken steps to ascertain its actual possibilities by arranging with one of the largest engineering firms in this country to send out one of their experts to make an exhaustive report. In due course they would communicate anything of interest in this respect to the shareholders.

A few words as to how he regarded the future of tin might be of interest to shareholders. As he remarked in his speech last year, he had no desire to prophesy. The price of £300 a ton was a very high one, everyone would agree, and if it were the result of speculation one might look for a crash sooner or later; but as far as he could gather this was not the case. What had really happened was—it was summed up to him the other day by a man who had had the longest and largest experience of any man in the tin market, and who had now no active interest to bias him—that there was not enough to go round: in other words, the demand was greater than the supply. As long as this position existed tin must, with certain set-backs from time to time, continue to have an upward tendency. He thought if peace were declared, the demand for it, for the time being, would increase, as stocks everywhere were depleted. He had had fifty years' experience of the produce markets, which had taught him how unwise it was to attempt to dogmatize on the future, but he thought this view of the tin market was at all events a common-sense one.

As regards the current year, so far they had produced 245 tons in five months, against 240 tons for the corresponding period last year, and, considering the rise of prices during that period, they were amply justified in taking a roseate view of their probable results for the year 1917-18.

Mr. Hugh C. Godfray seconded the resolution, which was carried unanimously.

The retiring directors (Mr. Oliver Wethered and Mr. H. C. Godfray) were re-elected, and Messrs. Annan Dexter and Co. were reappointed auditors.

A sum of 250 guineas was voted to Major A. R. Canning as a token of the shareholders' appreciation of his services, and the proceedings terminated with the passing of a vote of thanks to the Chairman, directors, and staff.

FORUM RIVER (NIGERIA) TIN CO., LTD.

Directors: James Gardiner (*Chairman*), Harry Cotterell, W. S. Coutts, Col. E. W Young *Secretary:* W. H. Stentiford. *Office:* 1, Broad Street Place, London, E.C. *General Manager in Nigeria:* A W. Hooke. *Formed* 1912. *Capital issued:* £72,500.

Business: Operates alluvial tin properties on the Forum and Du rivers, in the Bauchi region, Nigeria.

The fifth ordinary general meeting of the Forum River (Nigeria) Tin Company, Ltd., was held on December 21 at Winchester House, Old Broad Street, London, E.C., Mr. James Gardiner (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts, said that the past year had been a record one for the company, the output being in excess of any preceding year, and the net profits being substantially higher. In a company such as theirs, with a property 14 square miles in extent, which had only been prospected to a very limited extent, and which might prove capable of more economic working with hydraulicking or other machinery, they were of opinion that the time had come to create a reserve fund to provide for future contingencies, and it would be a wise and prudent course to place £5,000 to its credit. This enabled them to recommend the payment of a 15% dividend, and leave over £5,000 to be carried forward, out of which only excess profits would have to be provided. He was not in a position to make any definite statement with regard to the amount to be paid as excess profits tax, but he felt safe in saying that it would not exceed £3,000. The cost of production showed an increase—both so far as production at the mine was concerned and in the "all-in" cost—as compared with the preceding year, but this was only to be expected in view of the increased cost of all material. Although Nigeria was far removed from the principal theatres of war, the effects of the present world-conflict reached the mining plateau of Nigeria, and the increased cost of all commodities was apparent in the accounts received from their mine manager. Native workers were receiving a much higher rate of remuneration, and it was not necessary to mention that on all goods shipped from this side to Nigeria there was a very large increase, not only in the prime cost, but in all charges for freight, insurance, and other incidental charges. Bearing these facts in mind, the directors were not by any means alarmed at the figure shown as the average cost of production per ton. The increase in the cost of production was more than compensated for by the increased price realized, which showed a substantial improvement on the price realized during the preceding year.

Shareholders would remember that when he addressed them last year he dwelt at some length upon the question of the statutory percentage allowed for the purpose of excess profits duty by the Finance Acts. He informed them that the Nigerian Chamber of Mines was contemplating bringing the matter before the Board of Referees, with a view to getting an increase in the statutory percentage of 6%, and he expressed the belief that the authorities would not refuse to allow them special consideration. As the result of action taken by the Chamber the statutory percentage was increased from 6% to 13%, and in addition, under a more recent Act, any new money put into the business carried an additional 3%. The Board of Referees had recognized the principle that the alluvial tin-mining industry in such a country as Nigeria was entitled, as a matter of bare justice, to a substantial increase on the statutory percentage, but he ventured to think that the 13% now allowed could not be justified as the maximum to which that industry was entitled. It must be borne in mind that Nigerian tin companies paid the Government not only their ordinary income tax and excess profits duty, but very large sums in addition from which ordinary trading and commercial companies were exempt. A glance at their accounts would show that they had paid away in Government royalties during the year no less a sum than £3,273, and in addition to this there were, of course, the lease rentals, Government railway rates, and other payments, all of which went to swell the annual Government revenue. He ventured to hope that further representations might be made to the proper authorities, with the result of their being granted a statutory percentage more commensurate with the justice of the case.

As regards their staff and the year's work on the property, some twelve months ago, by an agreement between their neighbours, the Bisichi Tin Company (Nigeria), Ltd., and themselves, Mr. A. W. Hooke was appointed general manager of both companies. This involved their terminating the agreement they had with the Niger Company, Ltd., for the services of their engineers. Although most mining companies had had their difficulties through so many of the best men heroically coming home to immediately join the Colours, he was glad to say that by economic management the work on their properties had been satisfactory. In fact, the output for the expired seven months of their present financial year was very nearly the same as for the corresponding period of the year covered by their report and accounts.

While it was not possible during the year under review to launch out into extensive development work, Mr. Hooke had succeeded in acquiring another property for the joint account of the Bisichi Tin Company (Nigeria), Ltd., and their company, some 3¾ square miles in extent. The prospects of this new area were favourable, and in the near future they might reasonably expect revenue from this source. He refrained from saying more in respect to this at present, except that their best thanks were due to Mr. Hooke for the zeal and devotion he had displayed in the interests of his employers. It had not been his custom when addressing them to make prophesies with regard to the future, but last year he stated that, after four years of operations, they had a quantity of ore then proved to a far greater extent than the amount estimated by the engineers in their original reports, and he might safely amplify this now and say that after five years of operations they still had ore proved greater in extent than their original estimates. He could not refrain from reminding them of a further hope that he expressed last year, which was now fulfilled, and that was with regard to the dividend. When he explained last year the reasons which prevented them declaring a 15% dividend, he stated that he was sanguine enough to hope that that dividend was only delayed, and he was glad that the delay had only been one of twelve months. Further, and in conclusion, it was their intention to pay an interim dividend early in the New Year.

Mr. W. S. Coutts seconded the motion, which was carried unanimously.

THE KEFFI TIN COMPANY, LTD.

Directors: Charles Wallington (*Chairman*), M. H. D. Beresford, G. T. Broadbridge. *Assistant Secretary:* C. M. Swornsbourne. *Office:* 32, Sackville Street, London, W.1. *Formed* 1912. *Capital:* £50,000 in shares of 5s. each.

Business: Operates alluvial tin properties in Nigeria.

The ordinary general meeting of the Keffi Tin Company, Ltd., was held on December 27 at the office of the company, 32, Sackville Street, London, W., Mr. Charles Wallington (the Chairman) presiding.

The Chairman, in moving the adoption of the report and accounts, said they covered a period of eighteen months instead of twelve. Up to the date of these accounts the company had only been producing something like one or two tons per month, but, notwithstanding that, the loss shown for the whole of that period was very small, namely, £733. 6s. 11d. So far as the original properties of the company were concerned, no doubt they still contained a certain quantity of tin; but, according to the engineer, it was likely to be of a very small tonnage, and not at all certain to pay for getting it out. It was in consequence of this that the board looked about for additional areas, and they had been successful in being able to take up, direct from the Government, four new properties. The new properties consisted of two new leases, of 33 and 115 acres respectively, and two mining rights, representing over a mile of stream at Ambil Creek, and over 1,100 yards long on the Ayashi Creek. By the acquisition of these new areas, the position of the company had been entirely altered as from July last. From the month of July to the end of November no less than 72 tons of tin had been produced. The engineer stated that he expected to obtain an average over the whole year of something from six to eight tons per month, but already since the work was started the average production had been very much higher. In consequence of continued military service and demands on their time, Colonel Beresford and Captain Watkins had resigned from the board, and they had, at the same time, abandoned all claim to the fees which had accrued to them for the past two or three years, thereby effecting a saving to the company, so far as these accrued fees were concerned, of £600 or £700, as well as reducing the directorate. In place of one of the retired directors Mr. Broadbridge had consented to fill the vacancy, one reason for his election being that he had rendered great services to the Keffi Company, through another of his companies, in the matter of finance. The board of directors now only stood at three members.

Mr. M. H. D. Beresford, C.M.G., I.S.O., seconded the resolution, which was carried unanimously.

ST. JOHN DEL REY MINING COMPANY, LTD.

Directors: Sir Henry P. Harris (*Chairman*), Sir J. F. Remnant, Sir Edward Goulding, Col. H. Le Roy-Lewis, C. F. W. Kup (*Managing Director*). *Superintendent at the Mines:* George Chalmers. *Acting Secretary:* F. V. Steward. *Office:* Finsbury House, London, E.C.2. *Formed* 1830. *Capital issued:* £546,265 in ordinary shares and £100,000 in 10% preference shares.

Business: Operates the Morro Velho gold mine in Brazil; owns iron and manganese deposits.

The half-yearly meeting of the St. John del Rey Mining Company, Ltd., was held on December 13 at the City Terminus Hotel, Cannon-Street, London, E.C., Sir Henry P. Harris, K.B.E., M.P. (the Chairman of the company), presiding.

The Chairman, in moving the adoption of the report, said that the bullion produced during the half-year realized £242,620, which was £11,288 more than the amount realized in the corresponding period of last year. The tonnage was the same—namely, 94,300 tons—so the increase was due to a rise in the value of the mineral, the yield for the half-year having been 51s. 5¼d., compared with 49s. 0¾d. That was a satisfactory fact, especially as improvement in the mineral had been a regular feature in recent years, and had not only brought financial strength to the company, but encouraged them to hope for good results when the lode was being worked at depths still unreached. The profit shown for the half-year was £81,938, which was £9,739 more than that recorded in the December half of 1916, but £2,783 of that amount was due to a gain on exchange, which arose from the fact that their gold had been sent to New York instead of to this country. The directors consulted the Treasury and obtained their approval before taking that course. Quite recently they had received a cablegram from Mr. Chalmers, the superintendent, to the effect that the Brazilian Government were prohibiting the exportation of gold, but that the Government had accepted Mr. Chalmers' conditions for the sale of the gold and silver to the Government and for the remittance of the proceeds to this country. Of course, if the Brazilian Government paid the standard rate for the gold and the proceeds were remitted here promptly, there would be no disadvantage in the transaction from the company's point of view. The increase of profits obtained in recent years had its mournful aspect because of the excess profits duty. The question what ought be considered excess profits in their case had not yet been decided; it depended on questions still under the consideration of the board of referees. The development of the mine had made very satisfactory progress. An interesting piece of news had just arrived to this effect:—"242 level, horizon 21, driving east from 29 winze on course of lode; mineral satisfactory." That was an interesting event in the history of the mine, because it meant that they were now in touch with the lode 6,066 ft. below the surface. In July last the board authorized a prompt and vigorous exploration of the manganese deposits which had recently been discovered on the company's property, and a cablegram reached them recently to this effect:—"Manganese explorations, Lagoa Grande, quantity and quality very promising; exploring as rapidly as possible. Labour very scarce, especially at Morro Velho." Whether they would succeed in disposing of any of their manganese at the high prices which now existed he could not venture to say; it depended partly on the quality of the ore they might find, and partly on the possibility of getting any shipping facilities.

Sir James F. Remnant, Bart., M.P., seconded the motion, which was carried unanimously.

RHODESIA BROKEN HILL DEVELOPMENT CO., LTD.

Directors: Edmund Davis (*Chairman*), Lt.-Col. C. H. Villiers, Sir Edwin H. Dunning, Cromwell Hockley, Alexander Stewart, H. L. Stokes, Lord Teynham. *Consulting Engineers:* Hooper, Speak & Co. *Secretary:* T. Donald. *Office:* Salisbury House, London, E.C.2. *Formed* 1904, reconstructed 1910. *Capital issued:* £160,270. 15s. in shares of 5s. each.

Business: Operates a lead-zinc property in Northern Rhodesia.

The ordinary general meeting of the Rhodesia Broken Hill Development Company, Ltd., was held on December 31, at the offices of the company, Salisbury House, London, E.C., Mr. Edmund Davis presiding.

The Secretary, Mr. T. Donald, having read the notice convening the meeting,

The Chairman said: We regret not to be in a position to submit our report and accounts for the past year. Our meeting to-day is consequently formal, called to comply with the requirements of the Companies Consolidation Act, 1908, and will have to be adjourned until a date in the New Year when we shall be in a position to submit our report and accounts in the usual way. I take the opportunity which this meeting affords of giving you some information about the company and its properties. It should be remembered that the operations carried out refer to work done by the Rhodesian Lead and Zinc Syndicate, Ltd., during the period from April 1, 1916, to August 31, 1917, inclusive, in terms of the mining lease with which you are already acquainted. The period was one of active construction work and vigorous development, the objective being to erect as quickly as possible a lead-smelting plant capable of producing about 900 tons of lead per month, and equipping, developing, and opening up the mine in such a manner as to economically mine ores and fluxes in such quantities as necessary to supply the smelting plant. The transition from the experimental smelting stage to operations on a large scale was made with only a short stoppage of smelting, the small experimental furnace being put out of commission on June 21, 1917, and one new furnace blown in on June 25, 1917, the second being blown in on October 18, 1917. All the smelting ore mined during the period ended August 31, 1917, was won from No. 1 Kopje. The main orebody at this kopje consists of carbonate of lead with splashes of galena, flanked by zinc ore of good grade, with at places mixed lead and zinc ores. In the course of mining, large quantities of zinc ore and mixed lead and zinc ore have been separated and dumped for future treatment. The necessary fluxes of a quality suitable for smelting were mined, namely, ironstone 4,402 tons, dolomite 519 tons, and quartz 76 tons. In the course of mining high-grade lead ore for the smelter, approximately 20,000 tons of overburden was broken and dumped. This so-called overburden contains lead and zinc values, and is divided into two classes of ore: (1) ore high in zinc and low in lead, and (2) mixed zinc and lead ore. The prospecting work has proved the existence of two bodies of high-grade lead ore to the east of No. 1 Kopje. In the absence of pumping machinery, exploration has been confined to above the water-level, and only the caps of the bodies have been touched. The mine manager states that there is every indication of large bodies of lead ore existing below, and it is quite possible that both these bodies may be found at depth to form one large deposit with No. 1 Kopje. During the period under review, 9,764 tons of ore was smelted for a yield of 2,499 tons of lead. An extensive system of about three miles of tramways has been laid down, connecting the mine, which is half a mile from the treatment plant, with the storage beds, works, and railway, also for bringing in the wood fuel for the boilers. Everything to do with the development of the mine, erection and working of the plant, tend to prove that the undertaking should develop into a larger concern than contemplated, and it therefore became necessary to provide for additional capital expenditure. Purchases of traction engines had to be made to cope with increased transport, and stocks of wood and coke had to be accumulated for future requirements. The problem of housing accommodation for men and natives had also to be dealt with, necessitating the addition of white quarters and native huts. New offices had to be built near the works, and the old offices, three-quarters of a mile distant, were converted into quarters. A considerable amount of work has been accomplished with a view to opening up large reserves which are necessary in view of the capacity of the plant. In August last we issued 50,000 shares to provide part of the capital required, and obtained Treasury consent to the issue. It is now necessary to provide additional capital, and the Treasury has been applied to for consent to make a further issue of reserve shares. We have acquired the whole of the share capital of the Rhodesian Lead and Zinc Syndicate, Ltd., so that the whole of the profits earned by that syndicate, after providing for interest and redemption of debentures, will belong to this company. Arrangements have been made with the Central Mining and Investment Corporation, Ltd., to despatch some members of their staff to carry out certain work on the property with a view to their interesting themselves financially in the company. The all-important question of native labour supply has, on the whole, shown good results, and generally speaking has proved satisfactory. Owing to shortage of spares and difficulty in securing necessary supplies there will certainly be variations in the monthly tonnages produced, which at no distant date should average about 900 tons. This being so, a new contract has been entered into with the Ministry of Munitions, selling to it 800 tons of lead per month over the whole of 1918. Great credit is due to Mr. Macartney, the mine manager, and his staff for the manner in which the construction and development work has been carried out under somewhat trying circumstances; also to Mr. H. U. Moffat, the syndicate's manager at Bulawayo, for his unfailing efforts in bringing the mine to a producing stage. If possible when convening the adjourned meeting we shall also include accounts up to December 31. I now beg to move: "That this meeting stand adjourned to a date to be fixed by the board hereafter."

Sir Edwin H. Dunning seconded the resolution, which was carried, and the meeting accordingly stood adjourned.

MINERALS SEPARATION, LIMITED.

Directors: John Ballot (*Chairman and Managing Director*), W. W. Webster, Dr. S. Gregory, J. H. Curle, H. A. Krohn, F. L, Gibbs. *Secretary:* A. O. Williams. *Office:* 62, London Wall, London, E.C.2. *Formed* 1903. *Capital:* £50,000.

Business: The development and application of the flotation process in the concentration of ores.

The twelfth ordinary general meeting of Minerals Separation, Ltd., was held on December 20 at Winchester House, London, E.C., Mr. F. L. Gibbs presiding.

The Chairman, in moving the adoption of the report and accounts, said that the total income for the period under review amounted to £44,948, which exceeded the previous year by £6,688. A balance of £29,123 had been carried to the appropriation account. With regard to the appropriation account, the first item on the credit side of this account, namely, £50,352, was the balance of the profit and loss account as at December 31, 1915, less income tax. The second item, £99,942, represented the profit on the sale of the North American patents to the Minerals Separation American Syndicate (1913), Ltd., less income tax. In 1913 Minerals Separation American Syndicate (1913), Ltd., was formed for the purpose of acquiring the patents and business for North America. Minerals Separation, Ltd., received as consideration for the sale the allotment of 250,000 "B" shares of 10s. each, fully paid, in the 1913 Syndicate. These shares had recently been valued by the Inland Revenue authorities for the purpose of income tax at £125,000, the cost of the patents in question being £5,863. The authorities had assessed Minerals Separation, Ltd., for the purpose of income tax at £119,136 as profit resulting from the sale, and the tax in respect of this assessment, amounting to £19,194, had been incorporated into the accounts and would be paid by the company. On the debit side of the appropriation account, the first item represented the distribution to the shareholders of 250,000 Voting Trust certificates in Minerals Separation North American Corporation. In December, 1916, the Minerals Separation North American Corporation was formed with a capital of 500,000 shares of no nominal, or face, value for the purpose of acquiring all the undertaking and business of Minerals Separation Syndicate (1913), Ltd. The consideration for this sale was the allotment to the 1913 Syndicate of the whole of the 500,000 shares of the North American Corporation. Voting Trust certificates representing these shares were issued to the shareholders of the 1913 Syndicate. Minerals Separation, Ltd., as holders of 32,616 "A" shares of £1 each and 250,000 "B" shares of 10s. each in the 1913 Syndicate, received 315,232 Voting Trust certificates of the American Corporation. Of these 315,232 Voting Trust certificates 250,000 were immediately distributed among the shareholders of Minerals Separation, Ltd. The second item on the debit side of the account was the distribution of 12,000 Voting Trust certificates among the directors in accordance with a resolution of shareholders passed at the extraordinary general meeting held on March 14, 1917. The balance of £46,919 had been carried to the balance sheet.

It was with great satisfaction that the directors felt themselves justified in declaring, on the 18th instant, an interim dividend for the current year of 10s. per share, or 50%, payable less income tax on January 15, 1918. By the distribution therefore in 1916 and 1917 of trust certificates in the Minerals Separation North American Corporation, and by this cash dividend of 50%, it had been possible to make a good beginning in rewarding the patience which had been exhibited by the shareholders since the company commenced its operations. The North American Corporation was just finishing its first year of operations, and shareholders would shortly be receiving its first annual report. The management of that corporation's business was in the hands of Mr. Ballot, Dr. Gregory, and one of the partners of Messrs. Lazard Frères of New York.

On the occasion of the last general meeting they had good reason to feel gratified that the Supreme Court in the United States of America had upheld the decision given by Judge Bourquin in their favour in July, 1913. Since that date further legal proceedings had taken place in the United States with regard to the patent position there. The proceedings had resulted in their favour, and their Chairman, Mr. Ballot, had informed this board that as soon as circumstances permitted the American board would communicate direct to the shareholders of the corporation matters relating to its business, so that they would in future, as stated in the report just issued, look to that board for information regarding the North American business in which they were now individually interested owing to the distribution of trust certificates which had been made among them. Regarding the distribution to them of the 250,000 trust certificates which was made last year, shareholders who did not specifically request that the certificates to which they were entitled should remain in New York should now have received them from the Guaranty Trust Company of New York in London. Shareholders had also received information by circular issued on the 14th instant that the additional 50,000 trust certificates which the board in September last decided to issue were now ready to be delivered.

From the annual report shareholders would have noticed that the value of the new patents referred to in last year's report had been established, and they could congratulate themselves greatly in this matter. These new discoveries enabled them to treat a class of ores which only one year ago they were completely unable to handle. The possibilities opened up by these new discoveries which had been made by their expert staff in London were great, and there was every reason to expect that an important increase in their business would result therefrom. Ever since the war commenced their processes had been of considerable value in helping to produce metals essential for war purposes. and every new invention which they perfected increased the assistance which their company was able to render in this direction. In Wales it was likely that there would be several of their plants erected in the near future, as mines were being reopened there for the purpose of increasing the output of war material. In Norway steps had been taken to demonstrate the suitability of their processes for the treatment in that country of molybdenite ores and also for the treatment of all other ores for which the processes were useful. One of their engineers was now in that country and had just completed superintending the erection of a plant to treat molybdenite ores. It was expected from the exhibition afforded by that plant of the advantages derived from the use of their processes considerable additional business would result. Negotiations were proceeding which there was every reason to believe would in the immediate future result in an agreement being entered into between their company and a powerful French company having large mining interests in Spain and several other countries where at present their processes were not much known. It was not possible yet to provide details as to the proposed arrangement, but they anticipated that it would prove in the future of considerable advantage to the contracting company, as well as to themselves. In Russia, where there was a large field for their processes, it was at the present time impossible to carry on much work, but with the assistance of the International Russian Corporation of London and their Petrograd organization they were slowly, but surely, laying the foundation of business on a larger scale in that country when more settled conditions returned. Before the war, the Caucasus Copper Company became licensees and in 1915 they also granted a license to the Spassky Copper Company in Siberia, who had their plants in working. In Sardinia also for some time past a French company had been operating a small unit of the plant for the concentration of copper ore on the ordinary royalty terms, and arrangements were now being entered into for the commutation of these royalties in future by a cash payment and the transfer to them of a portion of the stock of the French company. It would be recognized that the principle adopted in this arrangement was a sound one both for the licensees and the licensors. In Bolivia a plant had been sent out to the Corocoro United Copper Mines, Ltd., and was expected to be in operation early in 1918. During the past year their works in London had carried out a large amount of experimental and research work, which was a most important part of their business, but the conditions had been difficult owing to so many of the staff serving at the front, while others were engaged upon pushing forward the production of metals in some of the Allied countries.

Mr. W. W. Webster seconded the motion.

The Chairman, in reply to a question regarding the Bwana M'Kubwa mine, said the company had signed and sealed an agreement with it, and they had an engineer ready to proceed to Rhodesia to erect the plant, and had models and patterns also ready for him to take out, so soon as the directors of the Bwana M'Kubwa company had signed their part of the agreement in exchange.

The resolution was put to the meeting and carried unanimously.

RUSSIAN MINING CORPORATION, LIMITED.

Directors : F. W. Baker (*Chairman*), A. Stanley Elmore, Lt.-Col. A. B. Haig, Walter McDermott, Baron Alfred de Gunzburg. *General Manager :* J. P. Hutchins. *Consulting Engineer and Responsible Agent in Russia :* A. Gernet. *Secretary :* Henry Richards. *Office :* 441, Salisbury House, London, E.C.2. *Formed* 1911. *Capital issued :* £245,250.

Business : The finance and development of mining and other projects in Russia ; has developed lead, copper, and zinc properties in the Altai ; has interests in drainage propositions in Petrograd and elsewhere, and in anthracite deposits in South Russia.

The sixth ordinary general meeting of the Russian Mining Corporation, Ltd., was held on January 2, at Salisbury House, London, E.C., Mr. F. W. Baker (the Chairman) presiding.

The Chairman, in moving the adoption of the report and accounts, said that the Petrograd suburban drainage scheme, in which they were interested, had not been proceeded with owing to war conditions. At the Russian Anthracite Collieries a reasonably good output of coal had been maintained at high prices, but the enterprise had been hampered for the want of transport facilities. With regard to the Altai Concessions, under the terms of the company's agreement with the late Imperial Cabinet they took over the right, for a certain number of years, to locate and develop mines within the area of two concessions in the Altai district, approximating about 14,000 square miles. They had just started to develop the concessions and to make their arrangements for unwatering some of the old abandoned mines when the war broke out. But for that fact they would, in all probability, have formed a large and powerful company, provided with ample working capital, to exploit and develop those valuable concessions. With the advent of war this programme became impossible, and they found themselves the owners of important mineral rights, over an extensive country, unable to proceed with any quick programme of development except under abnormal difficulties and at excessive cost. The directors, therefore, decided to enter into an arrangement with the Russian Trust and Finance Corporation to sell to them a 28% interest in all their rights in those two concessions for a sum equal to 50% of this company's total expenditures up to the date when the contract was entered into in January, 1917. This contract provided for a monthly payment to the Russian Mining Corporation of £2,500 to meet development and exploratory work, and as a result of this expenditure as applied particularly to diamond drilling on one of the old abandoned copper mines, located on the copper belt in the Zmeinogorsk concession, such encouraging results were obtained as warranted a systematic plan of diamond drilling on this property. This work had already disclosed an oreshoot of 3,000 ft. long, with a vertical depth of 650 ft. and an average width of 22 ft., indicating within those measurements a tonnage of 1½ to 2 million tons of ore, having a general average of 3½% of copper. As a consequence of this development, coupled with the evidence of the existence of a large tonnage of high-grade zinc-lead sulphide ore, carrying important gold and silver values, resulting from unwatering and diamond drilling on the Zyrianovsk mine on that concession, the directors were approached in the early part of the summer by a responsible group in Petrograd with a view to the formation by them of a Russian company to acquire from this company those two concessions, with a large amount of working capital to provide equipment for the two mines developed, and to carry out further exploratory work on other properties. The directors decided, as the development work referred to had practically proved the existence of two large base metal mines, the further development and equipment of which would involve large future capital expenditure, to negotiate with that group, and they finally agreed to sell their entire interests in those two concessions, subject to the consent of the proper authorities in Russia, for a price in shares which, after providing for the interest going to the original vendors and the Russian Trust, left this corporation with 36,000 shares of 100 roubles each in a company registered in Russia, and known as The Altai Mines, Ltd., capitalized with 100,000 shares of 100 roubles each, of which 25,000 shares of that denomination were reserved for working capital, and that capital guaranteed. This company had now been formed, the working capital had been subscribed, the Russian Mining Corporation had been allotted 36,000 shares, and they had sold 16,000 shares for 1,520,000 roubles, now deposited with the company's bankers in Petrograd. The reasons which influenced the directors' judgment in agreeing to sell were four—(1) the relief from the burden of having to finance through a war period the large expenditure involved in an enterprise of this magnitude; (2) the fear that as their concessions formed a part of the Imperial domains of the late Tsar their rights in those concessions might be confiscated, as indeed all Imperial domain lands had been, being now vested in the Ministry of Commerce for the benefit of the Russian people; (3) the very marked hostility to this company's interests evinced by those in control of the Imperial Cabinet interests in the Altai districts, and the fear that this hostility would eventually undermine their position with the Cabinet and prejudice their title; and (4) the advice the directors received from responsible Russian quarters to transfer the company's interests in those concessions to a Russian company at the earliest moment, having regard to the then strong revolutionary movement developing in Russia. Fortunately for the corporation, its rights were respected, and the authorization was obtained from the Ministry of Commerce to the transfer of those rights to the Russian company now formed, and he imagined that the Russian public must appreciate the validity of the transfer, otherwise he did not suppose they would have been able to sell as large a block of their Altai shares.

Mr. Walter McDermott seconded the motion, which was carried unanimously.

CHINESE ENGINEERING & MINING CO., LTD.

Directors: F. Cattier, Edmund Davis, E. Francqui, Lt.-Col. H. A. Micklem, G. T. Symons, W. F. Turner, Chevalier D'Oplinter de Wonters. *General Manager in China:* Major W. Nathan. *Secretary:* A. W. Berry. *Office:* 22, Austin Friars, London, E.C. *Formed* 1900. *Capital:* £1,000,000; debentures £1,104,000.

Business: Operates coal mines in Chi-li, north China.

The fifth annual ordinary general meeting of the Chinese Engineering and Mining Company, Ltd., was held on December 17 at Winchester House, Old Broad Street, London, E.C., Mr. W. F. Turner (the Chairman of the company) presiding.

The Secretary (Mr. Alfred W. Berry) having read the notice convening the meeting,

The Chairman said: We are holding this annual general meeting under peculiar circumstances. You will have learned from the circular which was issued on December 8 and from the notice of meeting which has been advertised in the newspapers, that owing to the non-receipt from China of the final accounts for the year ended on June 30, 1917, we are not able to submit to this meeting the directors' report and accounts for the year. The accounts for the month of June, together with the vouchers, schedules and inventory were lost by the sinking of the ferry boat between Nanking and Pukow. We had to consider what was the best course to be taken under the circumstances. In order to comply with the provisions of the Companies Act we have to hold our annual general meeting by the end of this year, and the question arose as to what should be done as regards the balance dividend which we have been in the habit of declaring at the general meeting in the month of December. There is sufficient information in the board's possession to satisfy us that the profits of the year, after making provision for income tax and for excess profits duty, which will amount to a large sum, will justify us in recommending a balance dividend of 7½%, free of income tax, which will make a total dividend for the year of 12½% free of tax, as compared with the total dividend of 10%, free of tax, for the year 1915-16. In view of the special circumstances of the time we felt that it might be a hardship to many shareholders if the declaration of this dividend were deferred until we are able to submit the directors' report and accounts, which would involve a delay of from two to three months. We came to the conclusion, therefore, that the best course was to recommend to this meeting the declaration of a final dividend of 7½%, free of income tax. If that is approved, the dividend will be payable on the 18th instant.

We propose to adjourn this meeting to a date which will be fixed by the board hereafter. The audited accounts, together with the directors' report, will be submitted to that meeting. A duplicate of the missing accounts has been prepared, and is on the way, but, as the mail now takes nearly two months, we do not think it likely that we shall be able to hold the adjourned meeting until the month of March. In the meantime, I need only say that the year has been a satisfactory one. The sales of the Kailan Mining Administration have been maintained, and there has been some increase in the profits, while the rate of exchange, which is an important factor, has been favourable to this company. I now move: "That a balance dividend of 7½%, free of income tax, be declared payable on December 18, 1917, making a total dividend for the year of 12½%, free of income tax."

Colonel H. A. Micklem, D.S.O., seconded the resolution, which was carried unanimously.

The Chairman: The only other resolution is: "That this meeting stand adjourned to a date to be fixed by the board hereafter." I beg to move that.

Colonel Micklem seconded the motion, which was unanimously agreed to.

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EDITORIAL

THE principles laid down by Mr. W. H. Goodchild in his series of articles on the "Evolution of Ore Deposits from Rock Magmas," now appearing in our pages, promise important application in other spheres than the genesis of ore. These principles explain many obscure points in metallurgy, metallography, and physical chemistry. Others of our readers than geologists will find the articles of unusual importance.

MINES are often given out-of-the-way names, which puzzle directors and shareholders in the matter of pronunciation. Some time ago a director, when speaking at a meeting, referred to the "Nigel" mine as the *Niggle*. This caused some consternation, for the *i* is usually sounded long and the g is given soft. The director, however, brought etymological evidence from "The Fortunes of Nigel," where Sir Walter Scott makes the illiterate Duke of Alsatia write the hero's name as *Niggle*. The name is Scots, and Sir Walter was learned in Scots lore, so the director won the day.

THE difficulty of maintaining attendance at the meetings of technical societies during war time is well exemplified by the experience of the Chemical, Metallurgical, & Mining Society of South Africa. On October 20, the president and five members of council were supported by an audience of seven, and the absence of the necessary quorum made the meeting purely informal. Nor is there any of the old difficulty of finding a seat at the meetings of our own Institution. For instance, Professor Louis saw many empty benches when he read his paper last month on mine taxation.

CONGRATULATIONS are due to the staff of the Imperial Institute, more particularly to Messrs. S. J. Johnstone and T. Crook, for the excellent pamphlet on "Zinc Ores" just published. This pamphlet gives particulars of the zinc-mining districts throughout the world, with statistics of distribution and production. It contains an outline of methods of valuation, and of the systems of concentration and smelting, together with information relating to the characteristics of commercial zinc, and the uses to which the metal and its compounds are put. It is written for the business man, not for the scientist or technologist. The complaint is sometimes heard that information of this class is never published in this country, but this reproach comes only from those who do not take the trouble to make inquiries. As a matter of fact the Imperial Institute has published monographs on many metals and minerals, such as nickel, antimony, cobalt, titanium, mercury, bismuth, tungsten, vanadium, molybdenum, tantalum, chromium, thorium, platinum, graphite, and asbestos. Moreover the staff is composed of well informed technical men, who are ever ready to advise and investigate.

ELSEWHERE in this issue will be found an article on the economics of copper production, by Professor H. C. H. Carpenter, of the Royal School of Mines. This article consists of extracts from the professor's Cantor Lectures on the progress in the metallurgy of copper, delivered before the Royal Society of Arts. The history of copper is of unusual interest at the present time, and unfortunately the literature covering the subject is scarce and difficult of access. For the benefit of those who wish to pursue the subject further we may mention that copies of Messrs. Nicol Brown and C. C. Turnbull's "Century of Copper" are still obtainable at the price of half-a-crown. Francis' "Smelting of Copper in the Swansea District" is very scarce. If any reader has a copy that he is prepared to sell, a notification to that effect would oblige.

IT is a trite enough axiom that gold mining can never reap advantage by means of a rise in the price of its output, but on the other hand suffers adversely from the advance in prices of materials and labour. Some authorities say that governments and banks should pay the mines more than 85s. per oz. Other eminent men have advised the closing of gold mines and the transfer of labour to copper, iron, or lead mines, inasmuch as gold is not really a useful metal. Between these two extreme limits there is an infinity of ideas and advice concerning the gold question. In the midst of all comes the imperative call of the banks for more gold and silver, commensurate with the vast expansion of trade, debts, and values. In the days before the war, the object of mining was to make a profit, but we forgot that the profits accruing from the existence of gold are not confined to the difference between output and cost at a mine, for gold in a banker's vaults is making profits all the while, providing as inexhaustible a flow as the widow's cruse of oil. Cannot the banks therefore afford to pay the mines a higher price than the par of currency? But before such an ideal object is gained, the use of gold for any other purpose would have to be suppressed.

The Science Museum.

The re-opening of the Science Museum at South Kensington presents a suitable opportunity for drawing attention to an institution the very existence of which is unknown to some people and ignored by others. Its name certainly does not help to advertise it, but rather tends to confusion with its bigger neighbour, the Natural History Museum. Nor do the Educational Authorities think highly of it, for they have dumped it in an old building which, if we remember rightly, did duty as a dining hall or similar purpose for the South Kensington exhibitions of 1882 to 1887; while the approach to the building from Exhibition Road reminds us of nothing so much as the entrance to the cheap part of the Hendon flying ground. The collection dates from 1867, and the object of the founders was to afford "information and instruction on the immense variety of machinery in use in the manufactures of this country." In 1876 a valuable gift by the firm of James Watt & Co. of many of the original Watt models added to the historical value of the museum. A notable expansion took place in 1884 when the models at the Patent Office museum were transferred. Purchases have been made from time to time, but the majority of exhibits have been given or lent by manufacturers and inventors, and chief reliance is still placed on this source of augmentation. It would be impossible for us to give anything like a complete account of the scope of the museum or of its contents, but a few points are of particular interest. The models and drawings of steam engines afford an excellent presentment of the development of the application of steam to power production, beginning with Hero of Alexandria, the Marquis of Worcester, and Newcomen, following with Watt, Symington, Trevithick, and Stephenson, and coming down to Parsons and Rateau. After the Watt models, to which reference has already been made, perhaps the greatest prize is George Stephenson's "Rocket," the locomotive which hauled the first passenger train on the Manchester and Liverpool railway. Pumps, air-compressors, and ventilating fans, constituting other branches of the power problem interesting to mining men, are also duly represented. One of the departments is devoted entirely to mining and metallurgical appliances. Here the collection is more miscellaneous than systematic, and our machinery houses could probably with little effort increase the value of this section of the museum. Nevertheless the various departments are of considerable interest, historically and currently. We find some examples of boring plant, and a fair selection of rock-drills. Models represent methods of mine timbering and shaft lining, and there are models of many things connected with hauling and hoisting, ventilating, and lighting. The early history of stamps, crushers, and breakers, and of concentrating machinery is illustrated by models and drawings, and in the metallurgical department there are a few models of furnaces, mostly relating to iron production, but also some applicable to the non-ferrous metals. As we have already said, the museum is capable of great expansion, provided the Government is favourable and our machinery friends and other engineers know of this opportunity and grasp it. We shall be glad if this short notice helps to make the museum better known and appreciated.

Potash from Blast-Furnaces.

The most interesting and authoritative paper describing modern methods of recovering potash as a by-product was presented by Mr. Kenneth M. Chance before the Cleveland Institute of Engineers last month. The author is a scion of that notable firm of chemical manufacturers, Chance & Hunt, of Birmingham. For some years an off-shoot of this firm, the British Cyanides Co., has been engaged in making cyanide compounds, particularly the prussiates of potash, from the by-products of gas, coke, and iron manufacture. At the beginning of the war attention was directed to the catching of potash, as such, from the dust of iron blast-furnaces, and, later, this work has been done under the auspices of the Ministry of Munitions. The Oolite iron ores of Cleveland, Lincolnshire, and the Midlands contain a larger proportion of potash in their silicate gangue than any other ores in Great Britain, so naturally the experiments were conducted in connection with these. The important part of Mr. Chance's communication relates to the extraction of the potash in the form of chloride, the reaction being brought about by the addition of common salt to the furnace charge. By a curious coincidence we have here an example of the reaction described by Mr. E. A. Ashcroft in the paper read before the Institution of Mining and Metallurgy just before Christmas, that is to say, the substitution of sodium for potassium in felspar at certain temperatures. Mr. Chance had previously tried the extraction of the potash as carbonate, but there were difficulties in the way of getting a good volatilization at a reasonably low cost. The chloride method has been found to be more easily regulated, and it is possible by its means to recover from 70 to 80% of the potash charged into the furnace without interfering with the iron reaction. Some doubt was cast on the possible deleterious effect of salt on the furnace linings, but the effect seems to be protective rather than destructive; in fact the salt promotes the formation of a glaze which tends to preserve the bricks. The relative amount of various chemicals produced by the reaction in the furnace depends, of course, on the nature of the charge necessary for the proper production of pig iron, and on the temperatures required according to the necessary variations in the constitution of the charges. It is clear that the furnaces must be run primarily for the iron, and that the practice cannot be altered for the benefit of potash recovery. Consequently at different furnaces the nature of the chemicals recovered varies considerably. In addition to the chloride, larger or smaller amounts of carbonate of potash may be produced, the cyanide constituent will vary, and soda salts and calcium chloride may make their appearance. Consequently the treatment of the raw by-products is by no means simple, and, for this reason, Mr. Chance advocates the pooling of by-products, and their refining and separation at a separate central establishment instead of the erection of refining plant by each iron-smelting company. Such a factory could mix the various raw materials to suit a constant method of treatment, and would also be in the position to maintain an adequate staff for research purposes. It is clear also that under present conditions the output and sale of potash in this country should be under Government control. A company has accordingly been formed, called the British Potash Company, the shareholders of which are the British Cyanides Co., the North Lincolnshire Iron Co., John Lysaght & Co., and the Government. The first factory, having a capacity of 25,000 tons of potash per year, has been erected at Birmingham, and eventually the yearly capacity will be raised to 200,000 tons. Other sources of potash, notably sheep's wool, will before long be available. It is estimated that in the district of Bradford, Yorkshire, there is at present running to waste from the wool-washing plants sufficient potash to meet the pre-war requirements of this country for potash in the form of carbonate. Mr. Chance has a small plant already installed to demonstrate the possibility of recovering this, at present, waste product. It is gratifying to hear from Mr. Chance that the potash position in this country is saved, and that the Government has bestowed its protection on the industry.

Mines and Taxation.

It is well that the Institution of Mining and Metallurgy is taking up the cudgels of the British mining industry against the destructive demands of the tax-gatherer. This action has followed the reading of a paper by Professor Henry Louis at the January meeting, in which, in forceful language, he urged that, if the Government had had for its object the bringing of British metalliferous mining to an end as speedily as possible, it could not have devised a more effective means than the present system of taxation. Professor Louis reviewed the incidence of taxation on mines under the various headings of income tax, excess profits tax, local rates, mineral increment value, and mineral rights duties. With regard to the first two items, everything possible has been said already by the press and by those in authority at each individual mine. But the Government takes no notice of the press, and arranges its enactments in such a way that concerted action cannot be taken by the mines. The Acts and Schedules are drawn by lawyers for the benefit of themselves and of the tax collector, and the procedure is arranged in such a way that the interpretation of the clauses and their application to each company are left in the hands of the assessors, who naturally do not hold identical views as to methods of handling their customers or of arranging the incidence of the taxes. The forces of the public interested in mining, sufficient, if acting concertedly, to impress the Treasury, are thus broken up into units, which can be defeated piecemeal. As Professor Louis said, until we have a Government Department of Mines with a representative in Parliament, who would both have an interest in the prosperity of the industry and be open to public criticism, mining will continue to be the defenceless butt of succeeding Chancellors of the Exchequer. Possibly the Department of Minerals and Metals recommended a year ago by the four mining and metallurgical societies might serve as a basis for a Government Department of Mines of wider power and duties, and we venture to encourage our Institution to press its agitation regarding taxation through this channel already opened.

The desired reforms in the application of taxation to mining cannot be too often defined. Professor Louis stated the case in concise and vigorous language, and there can be no mistake about his views. Other speakers at the meeting, Professor Frecheville, and Messrs. H. F. Marriott, P. D. Leake, and Humphrey Morgans, spoke in the same earnest strain. Both engineers and accountants are firmly united in their desire for the reforms, and their patience and perseverance will ultimately win. As regards income tax reform, the chief points centre round the general principle that "profits" according to the tax collectors should be the same thing as "profits" according to sound finance as laid down by accountants and business men. The taxing authorities have a way of upsetting all canons of economics by refusing to include in the working expenses anything but the cost of ore extraction, metallurgical treatment, and administration, and a trumpery allowance for depreciation of plant. The spending of revenue on development and renewals they consider to be an allocation of profits to capital account, and these profits can therefore only be transferred in this way after being docked of 25% for income tax. Similarly the provision for renewals of plant over 2½ or 5% per year is called an allocation of profits. Our only comment on these two points is that if due allowance for them were not made in the accounts and balance sheets as drawn up by the directors, the board would find themselves faced by other Government officials who would indict them for distributing unearned "profits."

The other item in connection with income tax that requires modification is the provision for the amortization of capital. A mine is a wasting asset, and dividends have always been regarded by shareholders as partly return of capital and partly interest on their money. It has often been said that the companies should make provision in their accounts for this continual depreciation in the capital value of the property, but for various reasons, notably the clumsiness of the legal proceedings involved, together with the wide variations in the prices at which shareholders individually acquire their holdings, such a policy has been generally deemed inexpedient. Before the war, when income tax was comparatively moderate in amount, shareholders did not find it onerous to pay the tax on the proportion of their dividends which they considered as return of capital, but with the tax at 5s. in the pound the position is different, and the taxing authorites must be urged to make some deduction from current revenue so as to remove this anomaly. Theoretically, as Mr. F. A. Govett said at a meeting of one of his companies recently, no profit can be considered as made by a mine until all the capital expenditure is recouped, but we cannot expect the taxing authorities to take this view, for the simple reason that shareholders do not do so. A more practical suggestion was made by Mr. H. F. Marriott in his remarks on Professor Louis' paper, when he proposed that during the latter years of a mine's life no income tax at all should be demanded, this remission being calculated as nearly as possible to provide for the redemption of capital. Other suggestions include the taxing of dividends and not of profits, but this would not be acceptable to the authorities because profits are often devoted to genuine capital expenditure on big extensions of operations and on the purchase of new properties, both of which are actually cases of the allocation of profits for capital purposes.

The income tax hits the mining companies quite hard enough, though shareholders will not kick in these days as long as the tax is based on real profits. On the other hand, the excess profits tax is excessively galling, particularly so to new companies or to companies that had no pre-war profits. It can hardly be expected that capital will be attracted by a proposal involving the payment of 25% as income tax, and 80% of the remainder, over and above a statutory maximum rate of dividend, as excess profits tax. There is no argument to be used against such a law; the mere statement is quite sufficient. The only attitude for contemplation is one of gaping incredulity. It is true that the authorities have granted concessions by raising the statutory maximum dividend for certain classes of ventures, but here again each company or each group of companies has to fight for favours. Concerted action by all mining companies, or by an accredited body representing mining interests, must undoubtedly be taken before equitable treatment can be obtained all round, both as regards the statutory maximum dividend for a wasting asset and the removal of the anomalous treatment of the new companies. Otherwise capital will drift away from mining, and the metalliferous mining industry will have to exist on Government doles. And not only are the companies actually conducting the mining operations to be considered in this connection, but the finance companies that provide capital by buying shares deserve to be included, for at the present time such companies are still subject to the 6% maximum return, which is of course quite insufficient for investments in mining ventures.

Professor Louis devoted some attention to the local rates levied on mines, a subject which we may discuss on some other occasion, and he proceeded to consider the case of the owners of mineral royalties and the onerous terms imposed on them in Finance Acts prior to and since the commencement of the war. The object of these enactments was to secure for the nation some part of the advantage accruing to the land-owners from the minerals underneath, and also to prevent the adoption of the dog-in-the-manger policy of royalty owners. We agree with Professor Louis that the terms of these new laws bear heavily on the land-owners, and that the inconveniences and costs arising therefrom will be usually passed on to the mining companies and to the public. Indeed the Acts are only clumsy, expensive, and inefficient means of arriving at the nationalization of unearned increment. But we would go a great deal further than Professor Louis. We believe that the average mining engineer and investor in mining ventures would encourage the Government to take its courage in both hands and apply more drastic and direct means of freeing the mining industry from some of the inconveniences of that "old man of the sea," the lord's royalty. It is high time that the efforts of commerce to develop ore deposits should be protected from the inconsequent whim and greed of the owners of the soil. The royalties accruing in future from ore deposits at present unproved should go direct to the State and not to the holder of the surface rights. Control of present dues should be vested in a Department of Mines, who should have the power to bring royalty owners together, compel them to grant long leases, settle equitable sliding scales, arrange for compensation for interference with the surface of the ground, and simplify the present legal processes. In connection with all these points the engineer and the capitalist continually receive rebuffs or find snags in their path. So long ago as 1893, Mr. J. D. Kendall roundly denounced the present system of royalties and wayleaves, in his book "The Iron Ores of Great Britain," and showed that they stood in the way of the proper development of our mineral resources, especially those that are lean. It may possibly be an exaggeration to say that the royalty question forms as great a block to mining as the taxation methods, but the hindrance is a very real and serious one, and its consideration ought to be taken in hand by the representatives of the mining industry without delay. We trust that the agitation to be inaugurated by the Institution will rapidly bear fruit, as regards both taxation and royalties.

The Empire's Coal Resources.

Last month we reviewed the proposals made by a Government committee for the more economical and efficient use of coal in the production of power and heat. The methods recommended will constitute a step toward the general conservation of the country's coal resources. The time is opportune to extend the inquiry and systematize the information relating to the coal resources of the Overseas Dominions and other countries of the world under British rule or protection. No doubt such a course will be taken before long by the Ministry of Reconstruction or some other suitable Government Department. In the meantime it is of interest to review the subject briefly.

In glancing through the various statistics available it is first of all obvious that almost every section of the Empire is blessed with coal deposits, though their extent, thickness, and characteristics vary widely. We will take Australia first. Of the several States, New South Wales possesses the coal of greatest extent and highest quality. The total area of the Permo - Carboniferous beds is between 15,000 and 20,000 square miles, and there are three centres of production, Newcastle, Illawarra, and Lithgow. The quality of the coal is good and it is suitable for steam raising and coking. There are deposits also of older Carboniferous coal, but this is so intermixed with shale bands as to be unworkable, and Jurassic coal is found in the northern part of the State, but so overlain by water-bearing sandstones as to present insuperable mining difficulties. In Victoria there are deposits of Jurassic coal in Gippsland and Tertiary brown coal at Morwell, between Gippsland and Melbourne. Mines are worked by the State in Gippsland, notably the Wonthaggi, but the resources are not very great, and attention is being turned to the Morwell deposits. These, as recorded in our issue of December, 1914, are of phenomenal thickness, three, one below another, measuring 230 ft., 265 ft., and 165 ft. respectively. As the moisture content is 25%, gasification and recovery of by-products is the policy indicated. The Queensland coals are of good quality, and extensive in area. Those found in the coastal regions to the south are of Jurassic age and are continuations of the beds over the border of New South Wales. These are not subject to the same water troubles as the sections over the border, and are extensively and profitably worked. Permo-Carboniferous deposits are found inland farther north. One of the outcrops, at Mount Mulligan, is described elsewhere in this issue. Another class of deposit, occurring in Cretaceous rocks, extends southward from the Gulf of Carpentaria and will no doubt provide supplies of fuel at a later date. In West Australia, the Collie coalfield near the extreme south-west contains deposits of Permo-Carboniferous coal, comparatively high in moisture, and it is being worked successfully. There are also deposits known in the Kimberley division, at the north-east corner of the State; these have not been prospected or developed. In South Australia coal has been worked at Leigh's Creek, 120 miles north of Port Augusta, but it is not of satisfactory quality. Tasmania has numerous small coalfields, of both Jurassic and Permo-Carboniferous ages, and the output is never likely to be large. In New Zealand there are deposits of Permo-Carboniferous coal and of Tertiary lignites, and mining operations are conducted in both islands at a number of places; no seam has a great area and the thickness of each seam varies in quite unusual manner. The reserves of lignite are much more important than those of the Permo - Carboniferous coal.

Coming now to Africa, extensive deposits of coal are being worked in the Transvaal, Natal, the Cape Province, Orange Free State, Rhodesia, and Nigeria. The coals within the Union are of Karroo age, that is to say, post-Carboniferous up to the Jurassic, and nearly the whole of Africa south of Pretoria is one gigantic coalfield. In the Transvaal the Middelburg collieries form the most important group of producers, and operations are also active in the Far East Rand, south-east of Heidelberg, and in the eastern Transvaal near Carolina and Ermelo. In Orange Free State the collieries near Vereeniging are of great importance, and there are also mines at Heilbron and Vredefort. The Natal collieries are in the Dundee and Newcastle districts. The only workings in the Cape Province are near Stormberg. Going farther north we find large areas in Rhodesia occupied by coal deposits belonging to the Karroo series. The Wankie coalfield is the only one at present producing, but to the north-east are extensive tracts known as the Lubu, Zengwe, Mafungabusi, Losito, and Luano deposits. The deposits in Southern Nigeria have recently been developed and, as recorded in our issue of January, 1917, promise to be of great economic importance. The coal seams at present known in Nyasaland are not of first-class importance, and those in British East Africa are of poor quality.

The extent of the coalfields of Canada is at present not fully known. The Alberta deposits are of enormous extent, and they belong to the Cretaceous age. In the adjoining province of Saskatchewan there are continuations of the same beds. British Columbian coal is well known, especially that mined at Crow's Nest, and the adjoining Vancouver and Queen Charlotte islands also possess important deposits. These beds are of Tertiary age, but are not continuous like those in Alberta. The coal seams of Nova Scotia, Cape Breton Island, and New Brunswick have been worked for many years. In the northern parts of the Dominion there are deposits in the Yukon, and very extensive deposits in the Arctic islands, where the conditions are somewhat similar to those ruling in Spitzbergen. The deposits in Newfoundland are extensive but little developed. The only other part of British America where coal has been found is Trinidad, where some deposits of lignite of medium grade have been prospected.

The British possessions in Asia and the East Indies are all favoured with coal beds. In India, the deposits of the Permo-Carboniferous age occurring in the Gondwana series are very extensive, and smaller amounts of Tertiary coal are also known. The coalfields of Raniganj and Djerria, to the north-west of Calcutta, are of great economic importance. The Satpura and Godavari basins are extensive, but not so fully prospected or developed. Other deposits of less importance are found in Burma, Assam, the Punjab, and Baluchistan. With regard to the Federated Malay States we have recently given particulars of the coal from the Rawang mine in Selangor. British North Borneo has a variety of coals of different horizons in the Tertiary, and some are being worked, notably the Silimpopon deposits near Cowie Harbour.

Any account of the countries within the British Empire having coal resources is not complete without mention of Antarctica, and of this region we published a description in our December issue. We may suitably conclude this brief review in the way we begun, and say that our possessions contain a big share of the coal resources of the world.

REVIEW OF MINING

Introductory. — The hopeless chaos in Russia is a serious matter both politically and industrially, and it looks as if mining operations in that country would come to an end before long. Under what auspices and conditions they will ultimately revive cannot be foreseen. The position of low-grade gold mines in various parts of the world is giving rise to much anxious thought owing to the margin of profit being wiped out by high costs. The eventual output of gold is being decreased by the more prosperous mines having to eliminate the lower-grade sections from their reserve. The price of tin still keeps high ; rules as regards dealing have been issued by the Metal Exchange. In Cornwall the notable event is the purchase of the lord's royalties from the Tehidy estate by Dolcoath and East Pool. The latter company has doubled its output of tin concentrate to meet the requirements of the Ministry of Munitions and is now producing 140 tons per month. This figure is much lower than that of Dolcoath 15 or 20 years ago, but it brings the company by a bound to the front under present conditions.

Transvaal.—The output of gold on the Rand during January was 694,191 oz., and in other districts 19,991 oz., making a total of 714,182 oz., worth £3,033,653, as compared with 697,137 oz., 25,282 oz., 722,419 oz., and £3,068,639 during December. The number of native labourers on January 31 was 176,424, as compared with 172,740 at the end of December, and 188,624 at the end of January, 1917.

Since writing of the 1917 Rand dividends last month, the Consolidated Main Reef has announced its dividend for the second half of the year. The amount distributed is £54,298, thus bringing the total distribution throughout the Rand to £6,635,734, as compared with £7,093,352 in 1916, £7,620,064 in 1915, and £8,070,659 in 1914.

When Springs Mines, Limited, obtained the Government lease of East De Rietfontein, Consolidated Mines Selection undertook to buy 200,000 new shares at £3 each, and acquired options on a further 300,000 at the same price. This arrangement has since been modified by Consolidated Mines Selection taking the latter shares firm, instead of holding an option on them, and undertaking to pay calls on them at the times and according to the amounts desired by Springs Mines.

Like other mines in the Far East Rand, the Daggafontein is experiencing water difficulties due to heavy inflow from the overlying dolomite. During a period of disorganization of railway service caused by abnormal rainfall, the bailing plant ceased work and the water accumulated in the shaft. On resumption it was found impossible to reduce the water with the present plant, so additional pumps are to be erected at the 2,000 ft. level. At shaft No. 2, which is down 519 ft., boreholes indicate the presence of much water below, so it has been decided to adopt the Francois cementation process. The water troubles arising from recent wet weather are not confined to the Far East Rand, for the lower levels at Village Deep have also been flooded.

Reference has been made several times recently to the Bleloch activities in the Far East Rand and Heidelberg districts. At a meeting of Houtpoort, Limited, held in London last month, it was announced that the company now owns the mineral rights over 600 acres on the farms Klippoortje and Tulipvale, between the town of Heidelberg and the Sub-Nigel mine. The report by Mr. Kotze mentioned that the continuation of the outcrop of the Nigel had been traced through Noycedale farm, to the north-east of Tulipvale, and Mr. Bleloch states that he has discovered its outcrop on Tulipvale. Mr. Bleloch calls it the Van Ryn reef, in accordance with his own interpretation of the geology of the Far East Rand. Further details are awaited.

Another mine on the Rand is rapidly approaching its end. This is the Glencairn, in the middle east, a neighbour of the May, which ceased production a year ago. The directors announce that difficulty is experienced in maintaining a payable grade, and that the reserves are nearly exhausted. There remains a considerable accumulation of old slime, which is now to be treated on a larger scale. Glencairn was one of the original Barnato properties, and was purchased from Knights. It was not one of the high-grade mines of the Rand, and dividends were only paid during 13 years out of a life of 29 years. The total distribution was 122½%, and it must be remembered that a considerable number of shares representing cash subscriptions were issued at premiums ranging from 50 to 200%.

At the meeting of the Johannesburg Consolidated, the chairman gave some particulars of developments and future policy at the Randfontein Central, control of which was purchased a year ago from Sir. J. B. Robinson. The last estimate of reserves under the old regime was 4,944,302 tons averaging 7·8 dwt. The average width over which this calculation was made was not given, but the purchasers ascertained that it was 44 in. This width was usually exceeded in the stoping operations, so the purchasers' engineers made a new estimate, their figures being 4,955,256 tons averaging 6·77 dwt. over 51 in. This reserve is inadequate for the big treatment plant at Randfontein, so extensive development was started, and at present the addition to the reserve is about 100,000 tons per month. The average assay-value of the ore developed is slightly higher than that of the reserve, a fact that promises well for the future. It is intended to sink two new shafts to a depth of 5,000 ft., to replace six shafts at present in use, which are obsolete in capacity and equipment. Not only will mining operations be greatly improved thereby, but more economical methods of pumping will become possible.

A new departure in connection with tin mining in South Africa has been taken by the Zaaiplaats company, which has recently erected a tin smelter. Until a few months ago the tin concentrate was sold to the Straits Trading Co. at Singapore. The cost of freight and the returning charges were so high that the company determined to start smelting and to find a local outlet for the metal. At the mine the reserves have been exhausted, but development on the lines recommended by Dr. G. S. Corstorphine continues to disclose ore. The veins and shoots are numerous, and many rich patches occur.

Rhodesia. — The output of gold during December was worth £270,616, as compared with £275,829 in November, and £306,205 in December, 1916. As we mentioned last month, the gradual decrease characteristic of the last six months is due to the suspension of operations at small properties. The outputs of other metals and minerals during December were: silver 18,557 oz., copper 332 tons, coal 50,809 tons, asbestos 493 tons, chrome ore 24,667 tons, diamonds 19 carats. The total yield of gold during 1917 was worth £3,495,391, as compared with £3,895,311 in 1916, and £3,823,166 in 1915. In our News Column we publish an excellent account of present conditions in Rhodesia, written by Mr. W. B. Blyth.

The Falcon gold-copper mine has joined the ranks of dividend payers, by distributing £80,000, less income tax, or at the rate of 20%, for the year ended June 30 last. During this period, 203,049 tons of ore was concentrated and smelted for a yield of 3,480 tons of blister copper, estimated to contain 3,414 tons of copper, 35,247 oz. of gold, and 70,876 oz. of silver. Owing to shipping difficulties the whole of this has not yet been realized. During the months July to September inclusive, 45,096 tons of ore yielded blister containing 961 tons of copper, 9,923 oz. gold, and 21,708 oz. silver. Mr. Cyril E. Parsons reports that the ore-shoot on the 10th level is not quite as long as in the levels above, but that the grade is as high. On September 30 the ore reserve was estimated at 859,026 tons averaging 5·3 dwt. gold and 2·39% copper; approximately half of this is broken ore in the stopes.

The reserves at the Globe & Phœnix are being maintained steadily. The figures at the end of December were 184,053 tons averaging 28·9 dwt. per ton, as compared with 173,981 tons averaging 29·5 dwt. at the end of December, 1916, 194,400 tons averaging 29·5 dwt. at the end of 1914, and 180,757 tons averaging 27·2 dwt. at the end of 1913. No estimate at the end of 1915 was published on account of the law-suit. Before 1913 the reserve averaged 32 to 35 dwt. per ton for several years.

Unusually severe storms have worked havoc in south-east Rhodesia. The Odzi River bridge, on the main line between Salisbury and Beira, has been carried away, and the railway has been damaged at three other points. A landslide choked the flume from the Odzi river supplying power to the Rezende mine. The stoppage of pumps caused floods in the bottom level and a cessation of milling. After an interval of a few days, 30 stamps were re-started and additional pumps were installed to unwater the bottom level.

Following the Rezende boom of two months ago, came a brisk episode in connection with Gaika. For a year or more the outlook at this mine has been gloomy. An unexpected cable last month announced the discovery of rich ore. The latest report states that on No. 5 level the north drift averages 24 dwt. gold over 88 in. for a length of 198 ft. driven. There was some excitement on the Stock Exchange, and the quotation bounded upward.

West Africa.—The value of the gold produced during December was £122,602, as compared with £126,915 in November and £146,409 in December, 1916. The output at Prestea Block A continues to decline. The total yield for 1917 was worth £1,529,977, as compared with £1,615,306 in 1916, and £1,706,473 in 1915.

At the Obuasi mine of the Ashanti Goldfields Corporation, exceptional difficulties have been experienced in connection with falls of heavy ground, particularly at the No. 13 level. Consequently the January output is less than normal. It is expected that the interruption will not last more than a few weeks. Readers who remember the article in our issue of September last will appreciate the problem involved in supporting the hanging wall at Obuasi. The company also announces that operations have been suspended for the duration of the war at the Ayeinm mine. The ore here is of low grade, and at the present level of costs does not warrant extraction. Moreover the stoppage will release much labour that can be more profitably employed elsewhere.

Australasia.—Some time ago Broken Hill Block 14 company acquired an interest in scheelite deposits on King Island, in Bass Straits between Victoria and Tasmania. A company, called the King Island Scheelite Mine, was formed, and Block 14 holds 42,000 out of 100,000 shares of 6s. each. A mill with a capacity of 400 tons per week started on July 26 last. Up to the middle of November, 3,673 tons of ore was mined and treated, for a yield of 53 tons of concentrate averaging 70% WO_3.

We announced last June that mining was suspended at the Mount Boppy gold mine, in the Cobar district, New South Wales, chiefly on account of the scarcity of labour. Cable advices are now to hand to the effect that stoping and milling were resumed at the end of last month. During the period that ore has not been raised, a new shaft has been sunk in the country in order to get at the ore left around the old main shaft. The new shaft is now in use.

The deal between the Queensland Government and the Chillagoe Company has been completed, and the mines, smelters, and railway are to be transferred. The company will still own the Mount Mulligan coal deposits, and on the strength of this fact the shares are reviving slightly. We give particulars of these coal deposits in the Mining Digest.

Cornwall.—After two years or more of negotiations, Dolcoath and East Pool have been able to make a deal with the owners of the royalties, and financial arrangements have been made whereby the rights are purchased by the mines. Full details are given with regard to this matter by our Camborne correspondent on another page.

The exigencies of the war have made it necessary for East Pool to treat a greater proportion of the rich ore of the Rogers lode in order to increase the output of tin. The policy of the controllers had been to hold this reserve in order to steady the output from the other parts of the mine where the ore is notoriously low-grade and refractory. But the immediate requirements of the Ministry of Munitions are not to be denied, so during the current year the output of tin concentrate will be increased from 70 to 140 tons per month.

For the second time during the last few months Stock Exchange movements have been interpreted as proof that the Rogers lode has been discovered in the South Crofty ground. Our information is that a lode has been intersected in the 225 fm. cross-cut, and that it assays 20 lb. per ton for a width of about 30 ft. Nothing has been published officially at the time of writing.

Canada. — The unreasonable antagonism of certain leaders of the profession associated with Canadian mining operations against the Minerals Separation patents continues, but the agitators are shifting their ground. First of all they tried to create a prejudice by asserting that the company is under German control. As this agitation has failed, it is now alleged that the claims made for royalties are so excessively high as to rule them out of consideration according to Canadian law. To this we rejoin that Minerals Separation is no child in legal matters.

In a recent public address, Mr. A. A. Cole, the president of the Canadian Mining Institute, drew attention to the mineral industry of Canada in the following words: "Our coal resources are among the greatest in the world. Our asbestos deposits in the Eastern townships of the Province of Quebec supply most of the asbestos of commerce. The greatest nickel deposits in the world are at Sudbury. Ontario has the largest body of high-grade talc on the continent at Madoc; the largest body of high-grade felspar on the continent in the Richardson mine near Verona; the greatest mica mine on the continent at Sydenham; and the greatest graphite mine at Calabogie. During 1916 also a molybdenite property was discovered within 25 miles of Ottawa that bids fair to outstrip all rivals. The tar-sand deposits of Northern Alberta are the most extensive in the world. We also have one of the richest silver districts in the world at Cobalt, and the most promising of the younger gold areas on the continent at Porcupine. Our smelters at Deloro and Thorold also produce more refined cobalt than all the other refineries in the world put together."

United States. — The *Engineering and*

Mining Journal estimates the output of metals in the United States during 1917 as follows: Copper 843,034 long tons, iron 38,367,853 long tons, lead 518,271 long tons, zinc 611,993 long tons, gold $84,456,600, silver 74,244,500 oz. The figures for copper, iron, and lead are slightly lower than those for 1916, those for zinc are slightly higher, and the silver figures are practically the same. All these figures are substantially greater than those for 1915. On the other hand the output of gold shows a steady diminution, comparing with $92,590,300 in 1916, and $101,035,700 in 1915. The *Journal* estimates the world's output of gold for 1917 at $430,000,000, and of copper at 1,413,056 tons.

In reviewing the comparative statistics of the gold output of the various states for 1916 and 1917 we find that the figures for Colorado are down by three million dollars, the rapid decline of this state as a gold producer during recent years being thus accentuated. California and Alaska are each a million less, and Nevada is two millions lower. The only state to show an increase is Arizona, which is up 1½ millions. The following table gives the chief figures:

	1916 $	1917 $
Alaska	16,124,800	15,171,300
Arizona	4,092,800	5,533,800
California	21,980,400	20,815,900
Colorado	19,185,000	15,955,100
Idaho	1,058,300	711,500
Montana	4,328,400	3,756,500
Nevada	9,064,700	6,922,900
New Mexico	1,350,000	1,025,100
Oregon	1,901,500	1,677,400
South Dakota	7,471,700	7,392,600
Utah	3,859,000	3,620,300
Washington	580,600	434,900
Philippine I.	1,514,200	1,404,000
Small yields in 10 other states brought the totals to:		
Total U.S.A.	$92,590,300	84,456,600

The following table gives particulars of the output of copper in the leading producing states. It must be remembered that labour disputes caused prolonged idleness in Montana and Arizona; otherwise the grand total would have been near the million mark.

	1916 Long Tons	1917 Long Tons
Alaska	51,750	41,030
Arizona	309,210	309,340
California	20,930	20,930
Michigan	130,560	122,070
Montana	157,140	122,680
Nevada	44,070	46,300
New Mexico	37,500	45,510
Utah	100,620	109,110
With the production of other states the totals amounted to;		
Total U.S.A.	867,310	843,030

India.—The developments at the Mysore mine have yielded little ore of high grade recently, and with the beginning of 1918 a larger proportion of lower grade ore is being treated. The January figures showed a yield per ton of 48s. 11d. as compared with 56s. 7d. in December.

Malay.—A Malayan Chamber of Mines has been formed in London.

Mexico.—The directors of the San Francisco Mines of Mexico, Ltd., announce that it has been possible to resume operations. The mines of this company are in the Parral district, Chihuahua, and were introduced in London as long ago as 1903. The ore is a complex mixture of sulphides of copper, lead, and zinc, carrying silver, and a suitable method of treatment has been difficult to evolve. A few years ago, Messrs. Knox & Allen, of New York, drew up a plan, and in the early months of 1915 the trial plant proved the success of the method. It was then decided to increase the capacity to 100 tons per day. Conditions in Mexico became so bad, however, that in September of that year the staff left the country, and the property was placed in the hands of Mexican caretakers. In the meantime the additional plant was delivered at El Paso, Texas, waiting for a favourable turn of affairs. A few months ago, the manager returned to the mine, and finding things in good order, determined that the plant should be forwarded. It is now being erected, and is expected to be at work soon. The authorities have promised an adequate military protection for the property and the staff.

Russia.—At the meeting of shareholders of the Spassky copper company, Sir Arthur Fell stated that at the Spassky smelting was being continued and that no steps had been taken by the Bolsheviks in the way of confiscation. Owing to difficulties in obtaining certain machinery parts, the output is less than normal. No payment is being received for the copper, and it has accumulated on the roads and railways, and at the smelter. Great difficulty is being experienced in paying the workmen, as the banks allow little money to be withdrawn. The only plan for keeping things going is to pay the men in goods from the stores, and to give credit notes for the balance. At the Atbasar mine it has been impossible to complete the construction of the smelter.

The Kyshtim Corporation announces that the Bolsheviks have published a notice of confiscation of the entire property, and its nationalization. So far no steps have been taken to enforce the decree. As regards the mines of the Irtysh Corporation, nothing has been heard so far of any expropriation, but the severe restriction of banking facilities and the entire disorganization of railway and other communications makes it inevitable that work will come to a standstill when the present supplies of material are exhausted.

THE ECONOMICS OF COPPER PRODUCTION

By H. C. H. CARPENTER,
M.A., Ph.D., M.Inst.M.M., A.R.S.M., Professor of Metallurgy in the Royal School of Mines.

This article consists of extracts from a series of Cantor Lectures delivered in December before the Royal Society of Arts on "Progress in the Metallurgy of Copper."

IN the last year of the 18th century, Great Britain produced about 75% of the world's output of copper. The Cornish mines supplied most of the ore, and the Swansea smelters extracted the metal. In the United States of America only a few tons were made. In 1913, on the other hand, the positions were reversed. Great Britain smelted and refined barely 6% of the world's production of this metal and all but an insignificant fraction of this was derived from imported ores, matte, blister copper, and precipitate or cement copper. In the same year the United States of America furnished more than 55% of the world's total and by far the greater part of this was obtained from home supplies of ore.

Whether in peace or war, copper is and has long been second in importance only to iron, not only in the various types of the commercial metal, but also in its numerous alloys. The enormously greater extent to which it is now used as compared with 100 years ago is, however, not so well known. In 1800 the world's production did not exceed 10,000 tons, and that was probably the high-water mark up to that time; in 1900 it had risen to about 500,000 tons and in 1912 to about one million tons. Thus in little over 100 years production had increased a hundredfold.

It is most probable that copper was the first metal commonly employed by mankind. It has been found in the native condition in various parts of the world, and the natural product required no metallurgical treatment prior to its use. The fact that it was very malleable and could be toughened by simple mechanical treatment undoubtedly contributed materially to its usefulness in primitive times. The mining and smelting of its ores have been carried on from time immemorial. According to Percy, the ancients obtained the metal from various localities, among which was the island of Cyprus where, according to Pliny, it was first discovered. The copper from this island was known in the Roman market as "aes Cyprium" or Cyprian copper. The adjective "Cyprium," at first used only to express locality, became corrupted into the substantive "cuprum" which replaced the original name "aes"; and from cuprum the English word copper is derived.

The Hindoos have smelted copper ores from the very earliest times, and to this day conduct the operation in small blast-furnaces about 3 ft. high. The deposits of Britain are said to have been known to the Phœnicians as far back as 1000 B.C. So far as I am aware a complete history of copper smelting in this country has not yet been written, but in the brief historical survey which I shall attempt, I wish to express my indebtedness to two important and most interesting sources of information. The one is Percy's "Historical Notices on Copper Smelting in Great Britain"; the other is Colonel Grant Francis' book entitled "The Smelting of Copper in the Swansea District of South Wales from the Time of Elizabeth to the Present Day," published in 1867. This book is largely compiled from evidence obtained in the Public Record Office.

Limits of time compel me to restrict my survey of the industry to a period which dates from the close of the 16th century. In the time of Queen Elizabeth there was a rich copper mine at Keswick in Cumberland, where, it is related, not less than 4,000 men were employed. This figure is regarded by Percy as a great exaggeration. There can be little doubt but that the ore mined was a sulphide. Webster, the author of the Metallographia, describes it as an ore "that must be often melted in the fire ere it be brought into the form of good copper." Perhaps I can best illustrate the state of the copper-smelting industry at the works connected with this mine by quoting from a letter from one George Nedham, probably an English smelter, to Sir Francis Walsingham describing his visit in company with a certain Jochim Ganse, who was a German smelter. The letter runs as follows:—"A description of the Doeinges of Jochim Ganse and George Nedham at the Copper Mynes by Keswicke in Cumberland A.D. 1581.

Right Honourable,—As soone as Mr. Jochim and I came to Keswicke, the firste thing we did take in hande was to searche out both the nature and the number of the hurtfull humors that were naturally bred in oure Copper ures gotten in that countrie wherein after sundrie trialls we attained to some perfection and found that in our copper ures, were tenn severall substance's whereof iiij ar visible w'ch ar iron, copper, a kinde of black stone (wherein the copper groweth) and a kinde of white stone named sparr: the other vj humors, w'ch are in the said ures, and invisible, ar sulpher, arsenique, antimony, vitriall, calcator and allom; so as in ten substances which ar in our copper ures, the copper is one, and the other substances by their naturall operation ar all hurtful and venomous humors to the copper; for some of them by wasteinge the copper in smeltinge and by their dryness make it bretle and black; the other by their toughe and moiste nature, be a great let to the speedie smeltinge and bringinge the ure into rough copper. The number, nature, and propertie of w'ch ix hurtful humors being wholly unknowne to Mr. Daniell and his sonne, or to any other of the Duch workemen w'ch have bin sente from Germany to the mynes, that have borne our copper ures, had bin the onely cause of the unreasonable charge and long tyme spent before they could make of those ures perfect rough copper: which copper after the order used in tymes past by Mr. Daniell and his son thei never could, nether yet can, make under xxij tymes passing thro' the fire and xxij weekes doeing thereof and sometyme more. But now the nature of those ix hurtful humors above said being discovered and opened by Jochim's way of doeing we can, by his order of workeinge, so correct theim, that parte of theim beinge by nature hurtfull to the copper in wasteinge of it, ar by arte maide freindes, and be not only an encrease to the copper, but further it in smeltinge: and the reste of the other evile humors shalbe so corrected, and their humors so taken from them, that by once wastinge and once smeltinge the ure (w'ch shall be done in the space of three days) the same copper ure shall yeeld us black copper and copper-stone, w'ch nether Mr. Daniell nor his sonne coulde or yet can do under xvj tymes passinge through the fire and xvj weeks in doeinge thereof: and further, in once rosteinge and once smeltinge the same black copper and copper-stone again, w'ch shall be done in ij days, after Mr. Jochim's order of workinge, I will bring the black copper and copper-stone into perfect rough copper, w'ch Mr. Stembarger cannot make under xxij tymes passing thro' the fire and xxij weekes in doeinge thereof and sometymes more!"

The letter then goes on to describe the part played by the 9 impurities in the smelting of copper and reveals a remarkably shrewd knowledge of their functions. Especially is this the case for iron, as the following quotation shows:—

"The vijth humor is Iron, being one of the vij metals but no mynerall w'ch being engendered and bred up in the earth with the copper ure, will not lightlie be gotten from it, and especiallie when the copper ure is smolten greene as it cometh from the myne, w'thout rostinge, then the iron doth joyne and incorporat himself w'th the copper . . . . w'ch is onely the greatest cause of so many chargable fires and longe tyme w'ch Mr. Daniell and his sonne do spende before thei can make rough copper. And accordinge to Mr. Jochim's order of workeinge the nature and substance of the iron yt is our copper ure being beaten into powder, and rosted as aforesaide, the drosse and corruption that is in the iron is so dryed up that when it cometh to smeltinge it is not able to runne or gether itselfe together like a slagge as it doeth being smolten greene before the ure be rosted: and the best substance w'ch is the right iron ure, beinge by rostinge brought into the perfection of iron, is, by the water and strength of vitriall, converted into copper, as I have proved sundrie tymes; so as this cheefe of the hurtfull humors beinge thus corrected it is made of an enemye a freinde and helper of the copper."

George Nedham, the writer of the foregoing letter, was one of the original partners of the Mines Royal Society, formed in 1580, to which I shall have occasion to allude shortly. The Sir Francis Walsingham to whom he wrote was the Secretary of the Society, which had just completed the erection of a copper-smelting works at Neath. I judge from the above letter that the best smelting practice at that period was to be found at the Keswick works where Daniell (whose surname was probably Hochstetter) and his son-in-law Stembarger, both of them Germans, were in charge and that they employed at any rate some German workmen. It appears that it took them 16 weeks to produce "black copper" and "copper stone" (our regulus or matte) from the ore and another 6 weeks to convert these into perfect rough copper, and that 22 furnace treatments were necessary. The Jochim Ganse was evidently another German smelter who undertook to smelt the ore much more expeditiously, and he and Nedham, apparently acting on behalf of the Mines Royal Society, made the journey to Keswick to carry out the test. That the latter was successful is evident for, according to the letter, black copper and matte were produced in 3 days, and another 2 days sufficed for their conversion into "perfect rough copper" which was the finished product obtained from the smelter. It is evident that previous to the appearance of Jochim Ganse at Keswick it took more than 5 months to convert the ore into copper, and it is clearly recognized that the chief cause of this very prolonged period was the presence of iron in the chalcopyrite. On the other hand, after two roastings and two smeltings Jochim was able to produce the same result in five days' time.

Following on this Nedham wrote to Walsingham in March, 1582, conveying an offer made by Jochim for "the makeing of copper, vitriall, and coppris, and smeltinge of copper and lead ures," in which he compared Jochim's charges with those of Stembarger, much to the advantage of the former, and recommended its acceptance. Moreover, it appears from the following extract from this letter that Jochim was to be engaged at the new works at Neath :—"And further the said Jochim doubteth not but that after he had rosted and smolten iij or iiij saies of o'r copper ure, in the great works, after such manner as he hath devised since his comeinge from Keswick, to attaine to such farther knowledg of the nature of all o'r copper ures in Cumberland and Westmoreland that he shalbe able to kill all the corrupt humors that be in them, and thereby to bring out more copper than heretofore hath byn."

I have given the above correspondence at some length not only on account of the interesting picture it gives of the condition of the copper-smelting industry in the year 1581 but because it describes the initiation of what must have been a veritable revolution in ore treatment as a result of Jochim's successful smelting of the Cumberland ores, and because so far as is known the smelter alluded to at Neath was the first to be operated in Wales and may therefore be regarded as the birthplace of the Welsh industry. It is notable, moreover, how closely identified with copper smelting at that time were German workmen. It is probable that the early ore furnaces of the primitive blast-furnace type in Britain were worked by Germans experienced in that class of work. The matter, however, did not pass without protest. Let me quote from a letter written by Mr. William Carnsewe to Thomas Smyth (January 15, 1583) who was the "Chief Customer of London to Queen Elizabeth" and the founder of the copper trade in the Swansea district :—"Mr. Weston's p'vydence in bryngyange hys Dutche myners hether to aplye such busynys in this countrye ys more to be comendyd then his ignorance of o'r countrymen's actyvytyes in such matters, who oute of all p'adventure be as skylfull in mynynge, as harde and dylygent laborers and as good chepe workmen in that kind of travell as are to be founde in Europe; whereof to make you good p'ffe lett the same Mr. Weston's Germans have some myn assignyd only to them, and lett yo'r Ulryke take suche as he is now acquantyd w'th of our countrymen, and the sam that wreoght in that worke at Treworthye laste when it was by Burchardys frowardness gyvyn ov'r w'che was abowte 23 yerys paste (1560) and let it be consyderyd w'che of them for on hole somers space shall put yow to moste chargys, and gayne yow moste, and soo of them that doo lesse yow shall make yo'r estymacyon by p'ffe." I have not been able to discover whether this test was carried out; it was certainly a fair one.

In the time of Elizabeth, James, &c., the metalliferous ores of this country were reserved to the Crown, and it was necessary to have a grant for the searching for and working of them, and further it was necessary to have a Patent or Crown Grant for the constitution of a company or aggregation of persons. The Mines Royal Society was constituted in 1580 and obtained its Charter in 1604. There were 24 shares, half of which were held by the English and half by foreigners. That the Crown shared in the profits of the undertaking is evident from a note or order on September 6, 1595, by Lord Burghley that "the Royal Company of Mines should certify what copper they have and how much they owe to the Queen and Customer Smyth's Exors. to answer for copper delivered." The Mines Royal Company lasted for more than 200 years and conducted operations at Neath. How small the scale of working was even at the end of that time is shown by the following extract from the books of Mr. John Place, their Manager:

"Oct. 10, 1796. Ores smelted this week 136 tons. Copper made 17 tons; Furnaces working 38; Coals burnt 315 tons."

From this it is seen that the weekly output of metal per furnace was less than ½ ton and that the coal consumption was 18·5 tons per ton of copper. The entry of May 16 in the same year is also interesting: "Coal so bad the men left the works for two days." To the Mines Royal Society Wales was indebted for the first copper works established in that country. Nearly one hundred years later two other companies started operations almost simultaneously in Glamorganshire. The one was Sir Humphrey Mackworth's "Company of Mine Adventurers" who established works at Melincrethyn, about one mile from the town of Neath, where great heaps of copper slag can still be seen. It was also known as the English Copper Co. Its charter dated from 1691 and it began work in 1695. It appears from entries in the records of this company that it was customary to employ criminals in their mines. Thus:—"Sept. 6, 1700. An account received that 17 condemned criminals had been pardoned by the King, provided they would within two months, apprentice themselves to Sir H. Mackworth and partners for five years, to work at the mines." "Oct. 16. Reported that two of the criminals sent to Neath had run away."

The other company was called "the Governor and Company of Copper Miners in England," and they erected works at Taibach. These were the pioneers of the famous copper-smelting and refining industry of South Wales.

According to Colonel Francis a document in the Muniment room of the Swansea Corporation proves that the first copper works in the Swansea area were erected in 1717. It reads as follows:—"In the year 1717 works were first erected upon the river at Swansea for smelting copper and lead ores which works are situated above the town and about two miles beyond the extent of this Corporation. In the year 1720 another works was erected upon Swansea river for the smelting of copper ores which is situated within the limits of the Corporation" at Burlaisbrook Junction with Tawe. The dates of the establishment of these and various other works as given by Colonel Francis may be tabulated as follows:—

TABLE I.—COMPANIES OPERATING IN WALES.

Place	Company	Date
Neath	The Mines Royal Society	1584
Melincrethyn	Mine Adventurers	1695
Taibach	Copper Miners	1727
Swansea	Lane and Pollard	1717–20
Penclawdd	John Vivian	1800
Llanelly	Daniell, Nevill & others	1805
Loughor	Morris & Rees	1809
Hafod	Richard Hussey & John Vivian	1810
Cwmavon	Vigors & Son	1837
Pembrey	Mason & Elkington	1846

It thus appears that copper smelting had been extensively carried on at or near Neath for a considerable period before it was established at Swansea and that it had attained a considerable degree of development there at least 120 years prior to its introduction into the latter town.

Let us now consider why the copper smelting industry came to be established in South Wales and the latter was able to maintain its position as the greatest producer in the world of the metal from the beginning of the 18th to the middle of the 19th century. The ores were mined in Cornwall and Anglesea. Why were they brought to South Wales for conversion into the metal? The Cornish pyritic ore was a by-product in the mining of tin and was originally thrown aside by the miners, under the name of 'poder.' In the eighteenth century several unsuccessful attempts were made to smelt the ore in Cornwall, of which a record has been preserved by Tonkin. Carew, in his 'Survey of Cornwall,' first published in 1602, wrote: "Touching metals: Copper is found in sundry places but with what gain to the searchers I have not been curious to inquire nor they hasty to reveal; for, at one mine of which I took a view, the ore was shipped to be refined in Wales either to save cost in fuel, or to conceal the profit." It is clear from the language of the writers of the 18th century that the Cornish mine adventurers regarded themselves the victims of a conspiracy on the part of the Welsh copper-smelters, but, as Percy shrewdly remarks, "It is difficult to understand why copper-smelting should have ceased in Cornwall if it had really been profitable. In one instance at least failure was not due either to deficiency of capital or incapacity in the management. As the adventurers felt themselves so much aggrieved by the smelters they might have entered into a combination to keep up the price of copper ore. Of all facts none are more stubborn than those of political economy; and the truth of the matter appears to be that copper-smelting can be conducted with greater profit in Wales than in Cornwall, and therefore it has become extinct in the latter county . . . . It would be difficult to select in this country a more eligible site for copper-smelting works than Swansea, and this for two reasons. The first is that it is a good seaport which is only at a small distance from Cornwall and Devonshire, the two counties in which the greatest amount of copper ore is raised, and it is also easily accessible to vessels conveying ore or products containing copper from South America, Australia, and other parts of the world. The second is that extensive collieries exist in the immediate vicinity from which an abundant supply of coal can be obtained at a low price. Many of the smelters are themselves engaged in the working of collieries and are thereby enabled to dispose of their coal to the greatest advantage, the large being sold at a good profit, either for home consumption or exportation, and the small, which is often very dirty from an admixture with shale, being reserved for the copper furnaces. It is advantageous both for the mine adventurers and the smelters that the process of smelting should be carried on in a locality where copper ores of various kinds may be procured, for it is well known that frequently copper can be extracted at a less cost by smelting several ores in admixture than by smelting any one ore by itself."

Few, I imagine, will disagree with the former reason advanced by Percy, but it is not clear to me that the latter had much if anything to do with the choice of South Wales for smelting operations in 1584. We must remember that at that time all smelting was carried out in small shaft or blast-furnaces and that charcoal was the fuel used. Coal was not, so far as I know, employed as a fuel in such furnaces. It appears, however, that between 1584 and 1700 the Neath metallurgists had discovered that the free-burning South Wales coal could be used for copper smelting and had evolved the reverberatory furnace for that purpose. Indeed this was a case where the character of the fuel rendered necessary a completely new technique of roasting and smelting. Information with regard to this most interesting change is unfortunately, I believe, entirely lacking. It is however important to note that in his letter of March, 1582, Nedham advances as one of the reasons for accepting Jochim's tender the undertaking of the latter to use nothing but peat in the roasting operations, whereas Stembarger and his father-in-law required to use wood. In the light of this it appears to me not improbable that Jochim and his co-workers would carry out tests on the coal so plentifully abundant in South Wales with a view to adapting it both for roasting and smelting operations. Be that as it may and whoever made this discovery, once the special adaptability of South Wales coal for reverberatory firing had been established and the technique of the new process worked out smelting practice in this country and on the continent diverged. In Central Europe, where enormous forests furnished wood suitable for making charcoal, a fuel which necessitates close proximity to the furnace charge, blast-furnace smelting continued to develop and exists to this day, the main difference being that coke has largely replaced charcoal as the fuel. In South Wales on the other hand smelting processes developed along the lines of reverberatory practice and resulted in the establishment of the famous Welsh process. The essential condition for successful reverberatory firing is that the heat must be applied at the right place, and that place is the charge on the hearth, not on the grate or in the flue. What is required is an abundance of incandescent solid particles burning with a more or less opaque yellow or white flame due to incandescence. A very large part of the heat utilized by the charge is received by direct radiation from these particles and it is this type of combustion to which the free-burning coals of the Swansea coalfield lent themselves in the reverberatory type of furnace.

After reverberatory furnace smelting had been established there was never any question but that Swansea was a most suitable location for the industry. Fuel was at that time the largest item of expenditure and remained so throughout the entire period of prosperity of the industry in South Wales. I have already quoted figures showing that at the end of the 18th century the consumption of coal per ton of copper produced was 18·5 tons for the mixtures then smelted. This figure had hardly been improved upon at all in 1861 when Percy published his book, for he there estimated that for every ton of copper made from a mixture of ores containing about the same proportion of this metal, 18 tons of coal were still needed. Accordingly a situation where cheap and suitable coal could be obtained was always of the highest importance to this industry. Whether the occurrence of high-class refractory clays suitable for fire-bricks and furnace linings in the immediate neighbourhood of Neath had anything to do with the choice of this place as the original smelting centre is a matter of conjecture. I am inclined to think that it had. At any rate the existence of the famous Dinas rock in the Vale of Neath was a fortunate circumstance for the copper metallurgists. It found application in the manufacture of furnace bricks and hearth linings, as also did the blown sands on various parts of the coast, some of the best qualities of which are found at Briton Ferry near Neath.

The Cornish ores previous to being smelted in South Wales were dressed and sampled at the mine. They consisted chiefly of copper pyrite, intermixed with small quantities of other cupriferous minerals, iron pyrite, and the constituents of the vein in which the ore was found. For convenience of dressing they were divided into three sizes by being dropped on to two rows of inclined bars which separated them into what were termed rocks, roughs, and smalls. Each of these then received an appropriate treatment in which hand hammering, followed by hand picking, rolling in a crusher and jigging played their part, as a result of which the copper ore was concentrated and yielded two products, the one known as "prills" and "smalls," the other as the "dredge." The former was the richer of the two in copper. These were subdivided into "doles" by means of a measure called a "barrow," which when filled with ore weighed about 1·5 cwt. The doles were sampled and assayed by the smelting companies' assayers, and on the basis of their results the various companies fixed the prices they offered at the approaching sale or "ticketing."

It should be remembered that the mining of copper in Cornwall was responsible for the introduction and successful working out of the use of steam power in engineering. "On account of the increasing depth and extension of the Cornish mines, the problem of disposing of the underground water became urgent, and led to the introduction of steam engines for driving the pumps, the Newcomen engine being installed on the Wheal Fortune mine in 1720. The success of this engine led to an increase both in depth and in extent of the workings, until it became impossible to cope with the pumping requirements by this means. At the right moment Watt brought out the modern steam engine and the first Watt engine was erected in 1777 at Chacewater in Cornwall. It was the introduction of these improved methods of pumping which have made possible the successful development of present-day mining. Not only has the steam engine thus led to an increase in the supply of copper by enabling the opening up of vaster deposits to be undertaken, but the development of engineering science which it has brought about has caused a further consumption of the increasing quantity of copper which it has helped to render available for use."*

In Great Britain the position to-day with regard to copper metallurgy is briefly as follows: The actual smelting of copper is a very small industry and in recent years the few smelters who do exist have found it more and more difficult to obtain smelting materials. The United States of America largely influences the price of copper—I am speaking of the situation before the war—and the policy pursued there is to attract smelting materials from other countries for treatment. The American can afford to pay a high price for imported ores because the remainder of his raw material is produced at home at a price which is so low that a low average selling price for the whole serves to secure an adequate profit. In the United Kingdom only a few of the large copper manufacturing firms and one or two companies owning mines abroad can afford to run smelting works under these conditions.

*Levy. "Modern Copper Smelting," pages 5, 6.

On the other hand a large number of manufacturers, not actual smelters of copper from the ore or matte, are engaged in refining blister, bessemer or other varieties of crude metallic copper and in producing the "tough" and "best selected" brands of the metal. The tough quality is used chiefly by the engineering and shipbuilding industries and is specified by the Engineering Standards Committee. A variety of this which is made almost exclusively in this country is the tough pitch arsenical copper, containing about 0·4 per cent of arsenic. This has a very extended application. The best selected quality is generally made in the form of ingots and is used for the manufacture of brass and other alloys.

These varieties are for the most part furnace-refined and I think I am correct in saying that in the production of this class of material our works in this country are pre-eminent. Much the greater part of the copper produced to-day, however, is electrolytically refined. In the United Kingdom the amount of copper treated in this way is very small and only some half dozen firms are engaged in this operation. In recent years several firms have discarded their plant simply because they found that they could not compete commercially with America.

The whole question of the future of the copper-smelting and refining industries in this country is being considered by the Non-ferrous Metal Trades Committee of the Board of Trade, under the Chairmanship of Sir Gerard Muntz. It is one of the highest importance. Until this report is published and made available, as I hope it will be, it would be improper to offer any further observations on the situation which exists to-day.

According to an estimate by Nicol Brown and C. C. Turnbull* the total copper produced from mines in the United Kingdom in the 19th century (1801-1900) was 864,660 tons, distributed as follows:

Cornwall and Devon	729,500
Ireland	69,000
Anglesea and other districts...	66,160

As regards Cornwall and Devon the mining of copper dates back certainly to the reign of Queen Elizabeth. It was obtained then—though in very small quantities—from mines at Perran Sands. The district was worked almost continuously from this period until the end of the 19th century, that is, for about 300 years. In most cases each individual mine

* Hunt's "British Mining," page 330.

had only a brief life. The following table† is given as the result of an investigation of the mines of this district for a period of 30 years:

35	mines lasted	20 years
40	,, ,,	10 ,,
31	,, ,,	5 ,,
114	,, ,,	less than 5 years.

In Ireland mining was carried on throughout the 18th and the greater part of the 19th century (until 1880). Anglesea produced copper in Roman times. Mines were opened up again in the 18th century and the industry carried on well into the 19th century.

The production and price of the metal in decennial periods is given by Brown and Turnbull as follows:

Period	Output. Tons	Price £ per ton
1801–1810	65,000	160
1811–1820	73,400	130
1821–1830	109,900	101
1831–1840	144,000	94
1841–1850	138,200	88
1851–1860	142,200	111
1861–1870	116,300	87
1871–1880	48,700	79
1881–1890	21,300	60
1891–1900	5,660	55

From this it is clear that the copper-smelting industry based on home ores underwent a great expansion in the period 1821-1830, that it reached its zenith in the next decade and maintained this with slight fluctuations for about 30 years, that between 1861 and 1870 a decline set in which was greatly accentuated in the succeeding decade, and that in the final period the production was less than one-tenth what it had been in the opening decade.

Let us briefly examine the history of the industry in these periods. Although, as I have mentioned, its chief seat was in South Wales, ores were also smelted and refined in the Midlands, South Lancashire, and Yorkshire. The expansion in 1821-1830 was due primarily to the use of steam-hauling and pumping machinery in the Cornish mines which enabled them to be worked to greater depths than before. Even at this time mining at a depth of 1,800 ft. was considered a great achievement. In the next decade foreign ores began to be imported into the United Kingdom, notably from Chile, and in the succeeding decade production began in the United States of America with a yield of 100 tons in the year 1845. Mining operations were begun in South Australia at the Kapunda and Burra-Burra properties, the ores being chiefly oxides. There was also a considerable amount of copper ore mined in Cuba. Notwithstanding the great increase in production of this period the metal was readily absorbed in the engineering and allied industries. In particular, copper and yellow metal were extensively applied to the sheathing of wooden ships. Most of the world's copper was sent to be refined at Swansea during this period, but from this time onwards the British copper-mining industry commenced to decline and Swansea became to a greater and greater extent dependent on foreign sources of ore. It was this development of foreign supplies and the unsatisfactory treatment which the producers received at the hands of the smelters which was the cause of the eventual displacement of Swansea from its position as the chief seat of manufacture.

From 1851 to 1860 was the critical decade. Early in the 19th century there was formed the Associated Copper Smelters at Swansea. On the authority of Brown and Turnbull, it may be stated that it was designed on the one hand for the purpose of keeping the prices of copper ore and regulus low, and on the other hand of keeping up the selling price of tough and other kinds of copper. This was a very favourable period for its operation, as there was abundance of copper ore to be had cheaply, and a great demand for the metal was growing up in the engineering trade. These large additional sources of supply made the Swansea smelters very independent and difficult to deal with. The modus operandi of the Association was to arrange a day in Swansea when the different parcels of ore were put in and ticketed, and these days were called the 'Swansea Ticketings.' Each smelter bid for the ore he required at his own price. It was supposed that there was a competition going on among the smelters, but practically there was none, as they largely agreed among themselves what they would pay for each class of ore and regulus. Chile had by now become the most important producer. In those days the ore was always carried in sailing ships, which, owing to their being wind-propelled, did not arrive with the regularity since accomplished by steamers, and many ships were thus, with a change of wind, brought to port on the same day. The smelters, watching these collective arrivals, regulated their prices for ore in anticipation of the ticketings and so secured large profits subsequently by raising the 'Associated' price for the metal when the operation was completed. In this way they sold, at a high price, the copper which they had ob-

†" A Century of Copper," page 24.

tained at a low price by their combination." The Swansea smelters thus forced the mine-owners to seek a remedy and this they did by smelting the ore either at or near the mines and exporting the metal instead of the ore.

In 1842 Lambert introduced reverberatory furnaces into Chile and they were so successful that in a short time they were in use throughout the country. In 1857 he erected the first blast-furnace there and the smelting industry there grew so rapidly that whereas in the period 1856-1865 the exports were in the proportion of ore 21·5 per cent, regulus 38 per cent, and bars 40·5 per cent, in the period 1886-1895 they were ore 1·5 per cent, regulus 3·5 per cent, and bars 95 per cent. The ultimate effect was to widen the market for the finished Chilean product and continental purchasers were thus enabled to obtain their supplies of metal direct instead of being obliged to purchase from the Welsh smelters on the unsatisfactory terms then prevailing. The rise of Chile as a producer of copper is evidenced by the following figures:

Decade	Production Tons
1831–1840	45,000
1841–1850	88,100
1851–1860	214,500
1861–1870	447,400
1871–1880	483,300

In the decade 1861-1870 Chile definitely took the lead as the world's greatest producer, contributing about half the total manufactured. This period is also memorable in that it witnessed great developments in mining at Calumet in the Lake Superior District, U.S.A., where the copper occurs native in quantities varying on an average from about 1 to 3 per cent in the ore-body. Percy states that in 1858 no less than 6,000 tons of copper were produced from this district alone. The ore is of three kinds, in each of which, however, the copper occurs native: (1) Vein deposits consisting of enormous masses of copper; (2) the conglomerate, in which the metal is tolerably evenly distributed and mostly in a fine state of division in the rock, the latter being very hard; (3) the amygdaloid, in which the metal is highly segregated and is found replacing other minerals. Some of the copper aggregates in the vein deposits are very large. Percy mentions that in 1854 not fewer than 40 men were engaged during twelve months in cutting up a single mass of native copper weighing about 500 tons. Native copper is generally remarkable for its toughness. A specimen from Chile about ⅜ in. in thickness is instanced by him as having been bent backwards and forwards 48 times before breaking.

The special feature of the next decade was the entry of Spain and Portugal as large producers of the metal from cupreous pyrite. Chile maintained its increased production and increases came from Australia and the United States of America. The Spanish and Portuguese industry had its origin in the following circumstances, described by Mr. Gossage in a paper read at the British Association in Manchester in 1861. A French trading company in Marseilles persuaded the King of Sicily that his revenue would be improved if he granted them a monopoly of the export of sulphur. The effect of this was that the price advanced from its orginal figure of £5 to £14 per ton. It was then discovered that our own Cornish mines, especially those in County Wicklow, Ireland, constituted an available source of sulphur of great value and chemists quickly devised methods of converting this into sulphuric acid. The King of Sicily thus conferred a great boon on this country since his monopoly was destroyed and considerable sums of money were beneficially circulated both in Cornwall and Ireland. The supply in these districts lasted from about 1840 to 1860, but at the end of this period was quite insufficient for the demand. New sources were then found in Andalusia in Spain and the adjoining districts in Portugal, and in succeeding decades those furnished notable quantities not only of sulphur, but also copper and iron. The San Domingos and Tharsis mines were reopened and passed under English management, and in 1876 the Rio Tinto Company of London took over the working of the famous mine of that name from the Spanish Government, and has continued to work it ever since.

This copper or cupreous pyrite is in most cases used first of all as a source of sulphur for sulphuric acid in the manufacture of sodium carbonate. In the early days of its use the residues were thrown out as waste. About 1862, however, the Henderson process for extracting the copper by a wet method from the burnt ore was invented and proved successful, and thereafter those residues were sold to copper smelters and had their copper extracted. The residue from this process left the iron in the form of ferric oxide containing a trace of copper and was known as "purple ore" or "blue billy." This was sold to iron puddlers and was used by them for lining the hearths of their furnaces, and in this way most of the iron was converted into metal. The ore thus became valuable as a source of its three chief constituents, sulphur, copper, and iron. The production of copper from Spanish and Portuguese sources is shown in the following table:

Decade	Production Tons
1841–1850	3,850
1851–1860	24,700
1861–1870	80,900
1871–1880	195,900
1881–1890	482,900
1891–1900	537,300

It was in the next decade, 1881–1890, that the United States of America rose to the position of the world's greatest producer and contributed about one-third of the total supply. The Lake mines expanded their output and both the Montana and Arizona properties were opened up and made large contributions. Spain and Portugal increased their output considerably, and in 1890 the Rio Tinto Company alone produced 30,000 tons. It was in this period also that ancient methods of production were superseded in Japan and modern processes introduced, in consequence of which that country became an exporter of copper. The credit for this is due to Professor (then Mr.) Gowland who went out from this country and erected modern smelting plant in Japan. The decline of Chile also dates from this decade, due to the exhaustion of the richer oxide ores which were once so abundant. Much the same thing happened in South Australia. This decade was also notable for the attempt of M. Secretan of the Société des Métaux, Paris, to obtain complete control of the output and price of copper which failed in the spring of 1889 when the price fell £35 per ton in one day.

In the next decade, 1891-1900, American supremacy was clearly established and that country produced more than 50 per cent of the world's copper. Very large increases of output took place at the Lake, Montana, and Arizona mines, and other districts, of which Utah was the most important, became producers. The rise and progress of the United States of America is set forth in the following table:

Decade	Production Tons
1841–1850	2,400
1851–1860	37,000
1861–1870	97,100
1871–1880	186,400
1881–1890	730,700
1890–1900	1,939,940

In the final decade of the 18th century that country produced nearly twice as much copper as in the previous half century. The strong position established by it at the end of the 19th century has not only been maintained but improved during the opening years of the 20th century, as the following table showing estimates of the world's smelter production in 1912 proves:

SMELTER PRODUCTION *

Country	Metric Tons
United States of America	592,400
Japan	67,000
British Isles	63,200
Australia	44,900
Mexico	44,000
Germany	39,800
South America	35,000
Russia	33,500
Chile	25,000
Spain	23,300
Canada	15,500
France	13,200
Europe (other Countries)	10,900
Serbia	7,400
Austria-Hungary	4,000
Italy	1,700
Total	1,020,800

Moreover the greatly increased demand for copper created by the war has been principally met by the United States smelters and refineries which in 1916 produced no less than about 865,000 long tons.†

As regards the consumption of the metal, in all some ten million tons were produced and consumed in the 19th century. In the early years of this period the bulk of the metal was absorbed in the engineering and shipbuilding industries, in railways, steamers, and in the application of steam power. Later on came its use as a sheathing of wooden ships either in the form of copper or yellow metal. The principal increase in production came, however, in the last decade and this was due predominantly to the discovery of the dynamo and the demand for copper in the electrical industry. It is estimated that this industry absorbed then and continues to absorb about two-thirds of the entire copper produced. The metal is specially prepared and sold under the designation "high conductivity copper," and in its manufacture electrolytic refining followed by furnace refining is necessary in order to obtain the requisite electrical conductivity and mechanical properties. The demand for electrical purposes continues to increase and has not been affected by the advance in prices.

* "Copper Handbook," Weed 1915.
† Estimated by the *Metal Bulletin*.

THE EVOLUTION OF ORE DEPOSITS
FROM
IGNEOUS MAGMAS

By W. H. GOODCHILD, A.R.S.M., M.Inst.M.M., F.G.S.

(Continued from the January issue, page 29).

In this series of articles the Author discusses the principles governing the segregation of ore deposits from rock magmas, introducing several new factors in addition to those already put forward by geologists. He shows how the specific action of certain gases and mineralizers, notably hydrogen and its compounds, together with changes in volume accompanying the later chemical adjustments, explain many obscure problems in the formation of ore deposits.

The Composition and Properties of Liquid Natural Matte.

In considering the question of the distribution and relative proportions of H_2S and metallic sulphides during the cooling process, the following points should be borne in mind: (1) H_2S and the monosulphides are of similar type, but the heat of formation of H_2S is very much less than those of the metallic monosulphides. (2) The monosulphides only of the metals are stable at high temperatures and these are all miscible with one another, in many instances in all proportions. (3) The higher sulphides can be prepared from the monosulphides by heating them under pressure with H_2S in the presence of moisture over a certain temperature range.

Taking these specific properties in conjunction with the facts and principles previously enunciated, it is practically certain: (*a*) that non-consolute drops of metallic monosulphides separate from a cooling rock magma at any early stage in much the same way as matte in smelting operations, but that the matte tends to contain a load of additional sulphur in the form of dissolved H_2S; (*b*) the composition of the separating matte is variable and varies continuously since it depends on the concentrations of the various components of the melt which in their turn vary as the separation proceeds. In a very basic iron-rich silicate magma, for instance, a greater quantity of lower sulphide of iron and a smaller proportion of sulphur as H_2S may be expected from the outset, while increase of total hydrogen in the melt or increase in SiO_2 would tend to increase the concentration of S present as H_2S in the matte; (*c*) the total H_2S in a rock magma distributes itself in such a way that its concentration tends to be high in the fluid monosulphides and low in the silicates.

Before proceeding to discuss the behaviour of this gassed matte at various stages in the cooling process it may be remarked that the dissociable sulphur of the ore minerals would appear to some extent to be a measure of the solubility of H_2S in molten monosulphides at elevated temperatures. Pyrite derived by cooling in an igneous magma may thus be considered as the result of freezing a weak compound or solution of H_2S in FeS, that is, FeS, H_2S, ferrous hydrosulphide, comparable in general chemical form with the hydrated oxides of iron, but unstable at low temperatures, breaking down into free hydrogen and a solid solution of sulphur, comparable in turn to the type of alloys known as intermetallic compounds. The existence of such a compound as FeS, H_2S stable only at high temperatures is well in keeping with the general chemical relationships of oxygen and sulphur. The accentuation of metal-like characters in sulphur by polymerization is suggested by its relationship with selenium and tellurium, the latter especially showing increased resemblance to the metallic type with increase in atomic weight.

In considering the behaviour of particles of gassed matte during the various stages of the cooling process, it will be necessary to briefly review some of the more important general changes that appear to occur over the temperature range. At high temperatures the matte consists of monosulphides containing dissolved H_2S and some free hydrogen. As the temperature falls some dissociation of the H_2S may occur simultaneously with solution of the liberated sulphur. Solution whether of H_2S or S is accompanied, particularly in the case of FeS, with considerable increase in density, since the sulphur dissolved in FeS is so highly compressed, as shown by the extraordinary density of pyrite. Although some hydrogen may be disengaged from the H_2S, it appears for the most part to be retained dissolved in the matte so long as this is still in the fluid condition. Quite apart from the geological evidence pointing to this conclusion, the capacity of many metals for occluding large but variable quantities of hydrogen and other gases when hot or in a molten condition should not be forgotten. We are thus confronted with an exceptionally complex and interesting study in two-phase, gas-liquid equilibrium. It is particularly noteworthy in this connection that accompanying the increase in density of the matte arising from condensation of the additional sulphur there is an opposing physical effect introduced by the increase in the concentration of the gases, hydrogen and H_2S, in the system. Superposed on this are the peculiar properties of cooling sulphur itself, which were briefly presented in a previous article. It is not difficult to see (1) that over a certain temperature range such gassed matte will tend to travel down temperature or pressure gradients to cool margins, a process that will be greatly facilitated by low viscosity in the magmatic bath; (2) that although the density of the sulphide system may be higher than that of the magma, yet, owing to its two-phase, gas-liquid constitution, transfer may take place in a direction directly opposed to that of gravitative descent, since the process is akin though not identical with the metallurgical process known as flotation; (3) the gassed matte on further cooling will have extraordinary penetrating power along rock pores, lines of weakness, or foliation planes in the solid rocks near the margin owing to its compressed state and the cutting power of the hydrogen, which becomes oxidized in the process to form water, giving rise among other things to the appearance of hydrothermal (aqueous) alteration on freezing. The genesis of contact deposits at the margins of batholiths and other igneous injections of the type formed before consolidation of the main bulk of the magma is thus easily explained. Such deposits usually show greater or less "hydrothermal" alteration together with iron reduction and variable amounts of replacement and modification of the minerals of the marginal rock, together with that sulphide penetration right into the mass of the marginal rock which has always been a difficult feature to explain on the current and vague solution or magmatic gas hypotheses.

Evidences of the operation of this kind of process exist at Sudbury, but the ore occurrences in the neighbourhood of the upper and acid margin of the eruptive, so far as the writer is aware, have not been described in any particular detail or exploited to any serious extent. It will be obvious that the same kind of action tends to occur at the lower margin of such an eruptive as the Sudbury before consolidation sets in, but the earlier concentration is apt to become mixed and confused with the results of the later processes. At Insizwa the results of this earlier differentiation to the lower margin are clearly shown in the sparsely mineralized hornstones separated from the later concentration in the mineralized picrite by an almost non-mineralized marginal zone of gabbro.

The Influence of Silicate Differentiation on Migration of Liquid Matte.

In the earlier presentation of the field geological evidence for gravitative descent of the sulphides at Sudbury, attention was drawn to the central core distribution of the basic differentiates in a number of igneous complexes and the preferential association of the ore minerals with these cores. The instances cited were all examples of magmas where extensive differentiation had taken place by the foundering of the heavy ferro-magnesian silicates in the melts. The Sudbury eruptive appears to have been partly differentiated on similar lines, but with this difference from the more basic melts to which reference was made, namely, that, whereas in the former the sinking silicates were either olivines or mixtures of olivine and pyroxene, at Sudbury pyroxenes only were involved. There seems to be little room for doubt that the presence of a preponderating sinking swarm of non-consolute silicates is an essential condition for the effective gravitative concentration of the minute quantities of more or less gas-impregnated sulphides in an igneous melt. Although the principles governing the early separation of fluid sulphides from a silicate magma are of general application and hold good for magmas of any composition, the whole trend of geological evidence in regard to the derivation of ore deposits from such acid magmas as granite, is diametrically opposed to the view that gravitative descent and local accumulation of sulphides is effected in the interior of granitic masses in a manner that is comparable with that which prevails in a rock magma subject to differentiation by the sinking of a preponderating precipitate of non-consolute silicates, but on the contrary the direction of the process tends to be reversed. For this reason then it is important to bear in mind the relationship between the composition of the Sudbury eruptive and the respective compositions of granite on the one hand and its basic differentiate on the other.

Some other Factors influencing Matte Migration.

Among the other factors that may have influenced the preliminary concentration and distribution of the sulphides at the lower margin two deserve some brief discussion, namely, convection currents and magnetism. As regards convection currents it may be said that it is in the nature of things extremely difficult to find definite evidence of the existence of such currents in igneous magmas by examination of the frozen melts, and the subject would be scarcely worth mentioning in this discussion were it not for views recently expressed that such currents are probably absent in cooling igneous magmas. Since these views have been based on experiments with anhydrous melts using very small quantities of material, any deductions based on the results of such experiments should be accepted with extreme caution, firstly on account of the essential differences between anhydrous melts and the pneumatically mobile natural magmas from which ore deposits are formed, and secondly on account of the differences in temperature between the top and the bottom of thick masses of igneous material arising from the natural increase of temperature within the earth's crust which accompanies increase in depth and the cooling complications that arise from this increase. A common feature of large sills is that known as "lateral migration," which may in some instances be an expression of convection currents, although in many cases it appears to be due to other causes.

Magnetic influences probably play an important part in determining the locus of the larger concentrations of sulphides formed during the cooling of such a mass as the Sudbury eruptive. That the earth is a magnet is a matter of common knowledge and that the strength of the field and the direction of the lines of force are also variable. Not only does the horizontal component vary, but also the angles of dip of the equipotential magnetic surfaces. In the case of small magnetic bodies suspended in a bath in which they are free to move in all directions it seems clear that they will tend to concentrate in the regions of maximum magnetic intensity. The magnetic properties of the pyrrhotites have been the subject of frequent comment, but experiments show that pyrite with only a small proportion of the sulphur eliminated by heating, that is to say, solutions of sulphur in ferrous sulphide of higher concentration in sulphur than the natural pyrrhotites, are much more strongly magnetic than the dilute natural solutions that are stable on solidification. From analogy with the magnetic properties of metallic iron it is probable that the sulphide solutions would lose their magnetic properties at some high and at present undetermined temperature, but there is geological evidence that suggests that at temperatures in the neighbourhood of those at which the sulphides may be assembled in or deposited from an igneous magma, such sulphides are liable to be influenced by earth magnetism. The more or less parallel pitch of series of ore shoots in many mineral veins traversing granitic rocks, where variation in the character of the wall rock cannot be adduced to account for the arrangement, a prevailing tendency for payable lodes to course more or less E and W, coupled with the fact that in parallel lode series it is often found that the shoots are approximately opposite one another and of similar pitch, taken in conjunction with the magnetic properties of many minerals that appear on heating strongly, suggest the influence of earth magnetism in producing certain types of ore shoots. It would thus appear that the feebly magnetic properties of the natural pyrrhotites in the solid state are probably but a gentle hint of a controlling agency of greater power at higher temperatures.

General Summary of the Natural Smelting Process.

In concluding this brief presentation of the factors that appear to be concerned in the preliminary concentration of the sulphides it will be both fitting and helpful to try and visualize some kind of mental picture of the whole process that precedes consolidation of the sulphides. It may be remarked by way of preface that if we assume that the magmatic bath was originally homogeneous in composition, or practically so, which seems on the whole to be the most likely condition, it follows at once that mere gravitative descent of the sulphides is no adequate explanation of the occurrence and distribution of the great ore-bodies at Sudbury.

The magmatic bath as a whole was so low-grade in the valuable metals that it is questionable whether the human metallurgist would have been able to extract anything whatsoever from it by his crude methods of matte smelting. Furthermore, supposing he did, his method would yield the matte as a relatively tiny button in the lowest and most unapproachable regions smothered in a hopelessly overwhelming mass of slag. It is worth while therefore for the metallurgist as well as the miner to observe the improved metallurgical processes whereby nature smelts out millions of tons of matte from hundreds of cubic miles of such low-grade material and puts it in positions where it can-be readily extracted for human use without the necessity for removal of such an enormous overburden of slag.

First of all the composition and constitution of the slag is arranged so that it shall have a very low freezing temperature range, so as to render the minute quantities of matte as insoluble as possible in the slag, and (2) low viscosity close down to the consolidation range so that the minute quantities of separated matte can be freely moved in the melt. These two fundamental requirements for ultra-low-grade smelting are obtained principally by a judicious addition of gaseous hydrogen and its oxide to the smelting mixture, the ratio of the volatile element, hydrogen, to its oxide being controlled reversibly and almost isothermally by the relative concentrations of the two oxides of iron acting in conjunction with the other oxides of different relative basicities present in the melt.

Instead of precipitating a "dead weight" liquid matte, the matte is gassed with a variable mixture of light and heavy gases, hydrogen, hydrogen sulphide, sulphur, etc., so that (1) its freezing point is kept low, (2) it is well protected from oxidation, (3) it can be moved about freely in all directions by variations of heat and pressure without sinking too hurriedly, (4) the composition of the separating matte may be varied continuously during the separating process in such a way that the first formed matte is richer in gases and consequently more easily concentrated by the other physical factors brought to bear on it, (5) it is most probably endowed with magnetic properties so that it can be arranged and concentrated in a magnetic field, (6) its density is increased by dissolving and polymerizing a greater or less quantity of the extra sulphur, thereby supplying it with a quantity of potential mechanical and chemical energy that is stored up for finally arranging it during consolidation, (7) the last matte to separate may be practically "dead" iron matte to catch as much as possible of the remaining traces of the more valuable metals and spread them in a more or less disseminated condition over a much larger area of the floor.

The slag may be and commonly is spread out in shallow basins, over large areas in a magnetic field of variable intensity instead of in tall steep-sided vessels, such as a blast-furnace.

We may picture the differentiation process as follows: A little of the gassed matte escapes down the temperature-pressure gradient to the upper margin and may give in this way a valuable indication to the prospector as to whether a sheet that has undergone crystallization silicate differentiation is likely to have anything in the way of ore deposits at its lower margin.

If the magmatic bath is big enough, as in the case of many batholiths, workable ore deposits may be formed in this way. The top margin, however, is apt to freeze up rather rapidly and before any great quantity of sulphides can escape from the melt, especially if it is inclined to be basic. Meanwhile the included suspended particles of gassed matte are lined up in magnetic bands under the influence of the magnetic field, but they are still free to travel in the zones of magnetic intensity along temperature or pressure gradients toward the cooling margins of the bath. The partly concentrated suspensions are next swept down to the lower cool margin more or less vertically by a torrent of sinking silicate crystals into regions of necessarily higher pressure and where in virtue of their superior gravity they tend to free themselves to a greater or less extent from the crystals, according to their degree of concentration, and to settle into hollows in the floor, but the first formed and gassiest matte will tend to run to the margin. The end result of the natural smelting process in such a semi-basic slag as the Sudbury is, instead of a single button in the centre or even a low-grade central core distribution of disseminated matte, great and seemingly sporadic masses of matte are accumulated in hollows well up the sides of the basin, which near the margin churn up the silicates, disrupt them on consolidation, expand and force their way either upward into the body of the eruptive or outward through the margin into the surrounding rocks by virtue of the peculiar energies of their dissolved gases, as will be shown later, and which fade away into the interior of the eruptive into plain pyrrhotite-norite showing no signs of that silicate replacement, which is such a characteristic feature of the richer and marginal sulphide concentrations.

Introduction to the Matte Consolidation Process.

The natural matte assembled in the neighbourhood of the lower margin of the eruptive by the combined action of the processes previously described consists essentially of the monosulphides of the metals iron, nickel, and copper, together with the sulphide of hydrogen, H_2S, and the products of its dissociation, hydrogen and sulphur. This complex solution or mixture yields, on freezing, the ore minerals pyrrhotite, pentlandite, and chalcopyrite, in order of solidification. This brief summary of the freezing phenomena is, however, obviously quite incomplete, for it gives no account of what becomes of the hydrogen, neither does it explain the behaviour of the dissolved sulphur and the accompanying silicate replacement and alteration, nor the mechanical effects of the freezing process as manifested in the partial expulsion of the sulphides from the eruptive into the surrounding country, the disruption and general brecciation of the marginal zone in the neighbourhood of the ore-bodies and the characters of that redistribution and rearranging of sulphides which taken together are among the more remarkable features of the consolidation phenomena.

In order to understand the freezing process as a whole it will be necessary to consider in some detail: (1) The constitution of the fluid matte and the minerals that separate from it; (2) the various chemical reactions that occur; (3) the physical aspects of the process, particularly as regards the volume changes involved.

In considering the constitution of the fluid matte it has to be borne in mind that it is the monosulphides of the heavy metals, iron, nickel, and copper in this instance, that are stable at high temperatures while as the temperature falls the affinity for additional sulphur to form disulphides gradually develops. It is important in this connection to bear in mind the dissociation temperatures and pressures of metallic disulphides.

When a gas, such as H_2S, dissolves in a liquid there is an evolution of heat, the heat of solution or absorption of the gas by the liquid, unless some chemical or physical change occurs that absorbs the energy that would otherwise be given out as heat. Now the heat of solution of H_2S in molten sulphides is an unknown factor as far as direct experiment is concerned, but despite the experimental difficulties that would be encountered in attempting to determine this factor quantitatively, there is no difficulty whatever in getting useful, if only qualitative, ideas of the effects of dissolving H_2S under pressure in liquid matte at elevated temperatures if we apply certain well established principles of physical chemistry.

It is pertinent to remark at this juncture that the whole subject of the chemistry of rock magmas and the derivation of ore deposits therefrom is to a large extent not such an unassailably difficult and obscure subject as is commonly supposed. On the contrary it is one that yields many of its more important secrets much more readily than might be anticipated when attacked with the aid of physico-chemical principles that have been established by means of the ordinary methods of laboratory research. Furthermore the validity of the reasoning can be checked up against the geological field evidence as presented by the frozen magmas and their mineral constituents, as well as by a mass of evidence that hitherto has scarcely been touched or utilized by geologists and mining engineers.

The particular problem now to be considered, namely, the state of the dissolved H_2S in the fluid matte, can best be attacked at the outset by way of the oxides and hydrated oxides of iron, which, unlike the corresponding H_2S compounds or solutions, are stable at ordinary temperatures. When an oxide hydrates the reaction is usually accompanied with an evolution of heat unless the energy is absorbed in producing some other change. When the oxides of iron unite with H_2O to form hydrates there is practically no evolution of heat, for the heats of formation of the hydrated oxides are almost identical with those of the anhydrous oxides. In the case of these iron compounds then, instead of a diminution in the energy of the system, such as occurs when heat is evolved, the energy is stored as potential energy within the system and manifests its presence in these instances by a diminution of specific volume or compression of the system.

The chemical analogies between sulphur, oxygen, H_2S, H_2O, and their corresponding metallic compounds are matters of common knowledge to physical chemists. There can be no question therefore as to the propriety of deducing the properties of solutions of H_2S in fluid sulphides from the corresponding properties of the hydrates or solutions of H_2O in the metallic oxides.

When H_2S dissolves in the liquid matte, then, we may infer with confidence that no evolution of heat occurs, but instead compression of the gas and increase in energy of the matte system.

Viewed from quite another standpoint it is also improbable that any great evolution of heat occurs in a reaction that takes place at such a high temperature as that of the molten magma at a period when it is well removed from its consolidation temperature range.

But the heat of solution depends on the molecular weight of the substance and rises simultaneously with the atomic weight of the electronegative radical. The atomic weights of oxygen and sulphur are 16 and 32 respectively. Again the thermal effect increases with rise in temperature. Combining these, we may infer that the heat of solution of H_2S in ferrous sulphide would be considerably greater than that of H_2O in ferrous oxide, but since it does not appear as heat it will manifest itself in some other way, which in this case is a correspondingly greater increase in density. The result will therefore be to yield a fluid matte of high density and correspondingly increased potential energy arising from polymerization or compression of sulphur or H_2S. Although the hydrogen subsequently escapes from the solution owing to the instability of the system at lower temperature, it is easy to check up the reasoning by analysing and comparing the densities of pyrite and troilite or pyrrhotite, with those of the oxides and hydroxides of iron, when it will be found that the contractions in volume in the case of the sulphides are much greater than is the case for the corresponding oxides. The writer has shown elsewhere that pyrite is nature's device for cramming the maximum of sulphur into the minimum of space. The formation of the preliminary compound or solution for generating pyrite, namely, FeS, SH_2, would therefore involve either the maximum of heat absorption from the magma or the minimum of heat evolution. Since at high temperatures the tendency is for such reactions to take place as are endothermic it is clearly probable that ferrous sulphide in a mixed matte will absorb H_2S preferentially to the other constituents of the matte and highly compress it, thus providing a prodigious amount of energy in a potential form for use at a later stage when the inevitable fall in temperature threatens to produce consolidation. Some further and rather striking evidence for the view that iron is the metal that develops its affinity for the second portion of sulphur in advance and at higher temperature than the other common heavy metal sulphides will be presented later when discussing the order and processes of formation of the ore minerals. It is enough at present to add that the common occurrence and modes of occurrence of the higher sulphide of iron coupled with its special physico-chemical characteristics are of themselves eloquent testimonies to the powerful affinity of iron or iron monosulphide for the second portion of sulphur at moderately high temperatures.

Easily Oxidizable Sulphides in Natural Matte.

In yet another important respect it seems probable that the artificial matte of the smelter differs materially from the natural product, namely, in the presence of small quantities of the sulphides of the alkali and possibly alkaline earth metals in the latter. This view is based rather on general principles than on direct evidence, as these sulphides of necessity would not appear as such in the frozen products. Some of the reasons for believing that they may occur in natural mattes are as follows: The addition of a proportion of these sulphides would probably help to lower the freezing range of the matte. One of the most striking features of the natural rock-forming silicate minerals is the multiplicity of the oxides that freeze out to form the crystal individuals, while the minerals show great variations in the proportions of the oxides in the same species. These facts, taken in conjunction with the general principle of opposing or prolonging the passage from the liquid to the solid state, point unmistakably to the conclusion that this complexity of composition is an expression of the physico-chemical efforts of the magma to postpone consolidation to as low a temperature as possible by building complex systems of relatively low freezing point. It may be remarked in passing that a rock magma seems to assume a kind of emulsoid constitution when in the near neighbourhood of the consolidation range, the phases being liquid-gas.

Since the same general principles apply to the sulphide sub-magma, there seems every reason to expect that similar reactions will occur during the formation of the matte so as to produce the greatest possible depression of the freezing range for any given magma composition. Judging from the specific chemistry of the sulphides of potassium, aluminium, magnesium, etc., there seems no difficulty in understanding their presence in limited quantities in natural matte while it contains hydrogen and hydrogen sulphide and the surrounding silicates contain free hydrogen. The foundation for the stability of these sulphides disappears, however, with the oxidation of the hydrogen, and they would of necessity oxidize on freezing and the metallic radicals would appear in the silicates after reducing some iron or hydrogen oxide. Their former mode of existence would therefore not be evident from ordinary petrographic research, though careful comparative chemical analyses might provide some interesting clues. The presence of potassium sulphide in natural matte would probably involve the presence of small quantities of silica as the two react together, so that it is possible that the small quantities of silica that are commonly present even in the purest natural magmatic sulphides may represent to some extent a residuum of dissolved silica that was not expelled during the freezing process.

The Composition of Matte and Rock Magma closely related to one another.

The composition of natural matte also depends largely on the composition of the magma from which it separates. Now the Sudbury magma is essentially an acid rather than a basic magma, for it does not contain a sufficient proportion of bases to saturate the silica, as is shown by the average composition and by the fact that on solidifying it yields a considerable quantity of quartz. For the purposes of considering the composition of the main bulk of the matte the average composition of the magma has to be taken, not the composition of either the acid or basic differentiates, since the sulphide-silicate magmatic split is a process that commences previous to silicate crystallization differentiation. The ordinary facts of industrial matte smelting go to show this, though it is probable from solubility considerations that some overlapping with the silicate differentiation does occur. The Sudbury fluid sulphides separated from a magma characterized by a considerable excess of silica over bases coupled with rather unusually high hydrogen concentration for a somewhat deep seated acid magma, the total hydrogen being shown as water in the rock analyses.

Now the sulphide of iron characteristic of acid rocks is pyrite, not pyrrhotite, though disseminated pyrrhotite may and does occur in frozen granitic magma for reasons that can easily be understood from what appears later. The reason for this is not far to seek, for free silica with the aid of H_2O at moderately high temperatures transfers part of the iron from a mass of FeS up to the saturation point of the residual FeS with dissolved sulphur, oxidizes it so that it combines with the silica to form ferrous silicate, which appears as chlorite or some similar mineral, while the saturated solution of S in FeS appears as pyrite or marcasite. These conclusions are fully borne out by a mass of geological evidence.

One more important point that has to be remembered is that, whereas the fluid matte is separated from a rather acid melt, the result of the silicate differentiation is to surround it with a mass of basic material before the sulphides start to solidify, and this basic mass is rich in iron. This solidification of the sulphides subsequent to that of the silicates seems to have been one of the stumbling blocks that have given rise to the idea that they were subsequently introduced by circulating solutions. Lastly it must be emphasized that the composition of the separating matte varies continuously as the precipitation process advances, because the gas pressure of the sulphuretted hydrogen distributed through the magma necessarily diminishes with the progress of the formation of the metallic sulphides.

The Earlier Stages of the Matte Consolidation Process and some collateral effects.

We can now proceed to consider the consolidation phenomena and the later stages in the building and internal differentiation of the ore deposits. By way of preface it may be remarked that whereas hitherto the tendency of the chemical processes described is inclined to be either endothermic or to be accompanied with a minimum of heat evolution, the turn of the tide is now reached and the tendency of the processes is to be exothermic, thus tending to prolong the period of fluidity in conformity with the fundamental principle of partial annulment of the temperature factor.

The first step toward consolidation is probably the slow escape of a portion of the hydrogen from the matte. Now it is well known that hydrogen is capable of diffusing through solid silica at moderately high temperatures. This is ascribed to interpenetration of the hydrogen molecules between the interstices of the silica molecules. But the complex character of the natural rock-forming silicates points to their being even larger and more highly associated molecules or systems than those of SiO_2 itself, so that hydrogen should diffuse through these with even greater ease. This hydrogen, however, does not get very far afield from the sulphides before it gets oxidized to water at the expense of Fe_2O_3 in the ferro-magnesian silicates, reducing the ferric to ferrous oxide.

These two oxides are of essentially different types as regards their molecular configuration, consequently strains are set up in the pyroxenes or ferro-magnesian silicates, with the result that they recrystallize to hornblende. The H_2O so formed is probably, though not necessarily, retained in the hornblende, causing slight hydration. The commonly observed presence of a greater amount of hornblende in the neighbourhood of the ore-bodies at Sudbury and other similar occurrences is thus due to a gas-solid diffusion and oxidation of hydrogen liberated from the fluid matte, while the formation of hornblende containing water of constitution from pyroxene may be compared with the prooess of "slaking" lime, so that we may regard many hornblendes as "slaked" pyroxenes.

Just as slaking lime causes the mass to swell and give out heat, so the formation of hornblende from pyroxene would probably be exothermic, while the general relationships of the amphiboles to the pyroxenes show that the amphiboles are of slightly lower specific gravity than the corresponding pyroxenes. This final hydration of the basic minerals previously crystallized from a magma is probably a much more general feature of the consolidation process than is commonly supposed. The water of constitution of a magma is the oxide of lowest freezing point, apart from the gases such as CO_2, so that its presence in the free state is required up to the last to prolong the fluid life of the constituents that solidify after the basic crystals have formed. The commonly observed alteration of pyroxene to hornblende or diallage can be easily understood on the hypothesis that the hydrogen and its oxide, after having performed their function in regard to the later solidified constituents, slightly hydrates or "slakes" the basic constituents, that is to say, we are dealing with one of those transformations after consolidation with which the metallographer is so familiar. In the case of such a rock as granite it is most difficult to understand the order of consolidation, or how the solidifying temperature range is so low, in view of the melting point of silica, on the assumption that the hydrous mineral muscovite mica as such is the first to separate. The difficulty vanishes, however, on the hypothesis that an anhydrous basic mineral separates first which hydrates approximately contemporaneously with the solidification of the silica; furthermore the hydration process would probably be exothermic and tend toward that partial annulment of the temperature factor, which may be regarded as one of the fundamental principles governing the whole consolidation scheme. In the case of hornblende the variations in structure are doubtless connected with the variation in the proportions of the oxides on the one hand, and the temperature and pressure conditions under which the hydration is conducted on the other. The formation of hornblende and similar hydrated minerals illustrates clearly the basic weaknesses and pitfalls of microscopic petrography as a science divorced from physical chemistry, and the fact so convincingly established by metallographic researches that in the case of the cooling phenomena of heterogeneous systems in general "it is rarely possible to interpret correctly the results of microscopic investigation without some knowledge of the diagram of thermal equilibrium." The greater accumulation of hornblende in the neighbourhood of the ore-bodies also implies greater local accumulation of pyroxene, which in turn results from entanglement between sulphides and sinking pyroxenes during the preliminary concentration. The hydrating reaction being exothermic and involving expansion also helps a little to prolong the magmatic life of the sulphides, particularly as these expand on solidification, as will be shown later.

The continued escape of hydrogen from the matte naturally jeopardizes the existence of any readily oxidizable sulphides that may be dissolved in it. Such sulphides as potassium sulphide for instance would tend to pass out and become oxidized through the medium of H_2O generated by the interaction of the escaping hydrogen with the oxides of iron. Compare in this connection the phenomena of propylitization. Such liberated K_2O or other alkaline oxides would at once attack neighbouring silicates. The petrographic relationships between biotite and the sulphides, both at Sudbury and elsewhere, is so peculiarly intimate as to strongly suggest that its constituents are derived in part, though perhaps not wholly, from the molten sulphides. That potassium rather than sodium should be the metal to be preferentially absorbed in natural matte can be well understood on account of the weaker affinity of K_2O for silica at high temperature as compared with Na_2O, while the local introduction of some extra alkali in this way is also calculated to help in the later disintegration of silicates. Biotite, of course, is formed by other means, and the preceding explanation applies only to the local excess concentration of biotite often observed to occur in the neighbourhood of magmatic ore-bodies, not merely at Sudbury but elsewhere.

(*To be continued*).

The Alaska output of minerals and metals during 1917 is estimated as worth $41,760,000, a fall of $6,870,000 as compared with 1916. The chief product was copper at 41,030 long tons, worth $24,000,000. These figures were lower by 10,720 tons and $5,500,000 as compared with those of 1916. The output of gold was worth $15,171,300 as compared with $16,124,800. Of the gold, $9,850,000 came from alluvial mines. The production also included silver worth $1,050,000, tin worth $160,000, lead worth $160,000, and antimony worth $40,000.

LETTERS TO THE EDITOR

Mines and Publicity.

The Editor:

Sir—The subject dealt with in Mr. Stephen J. Lett's letter and the editorial note in your January issue is one to which I, a mining journalist, have had, necessarily, to give a good deal of attention.

Mr. Lett's suggestion is that the shareholders of every mining company should appoint a "technical auditor" who "should be required to do such work as is necessary to certify under the annual report" that . . . "the report exhibits a true and correct view to date of the value and condition of the mining property. In short he will in effect certify that not only the truth but the whole truth has been told in the report."

Although you have given the heading "Auditing" to Mr. Lett's letter, I think you will agree with me that, actually, the wider question of mining publicity as a whole is raised once again.

In your accompanying editorial you contend that "there is no extensive necessity for an engineering auditor," that, nowadays, "it is seldom that any glaring misstatement is possible," and having "read practically every yearly report of the mining companies known in London issued during the past eight years" you "consider that their standard of fairness is high."

I agree with you that it is seldom any glaring misstatement is possible. But this is only one phase of the question, and the last sentence in my quotation from Mr. Lett's letter gets nearer to the root of the matter. My experience—which as you may know is a fairly lengthy one—is that the withholding of material information from the general body of shareholders has done more harm than the making of glaring misstatements. It is not enough that the statements directors choose to make should be truthful; shareholders should be given the whole truth.

Nor would it be enough in the case of all mining companies for a "technical auditor" to certify under the annual report. What of the development cables, and the manager's weekly or monthly reports? A full disclosure of the facts, "the whole truth," might be given the shareholders once a year and yet they might be "let down" by the directors withholding a certain piece of material information during the twelvemonth.

I have had occasion to investigate a number of cases of the holding-up of information by directors of mining companies. The evidence has not invariably indicated that the policy adopted was deliberately decided upon after mature consideration. Sometimes those responsible for the publicity policy had simply let things slide.

A "technical auditor" acting once a year would not meet all the requirements of the case. What are wanted are: *(1)* a larger number of men to act as directors who have technical knowledge, who recognize the rights of the general body of shareholders, and who are not concerned more about the share market than about legitimate mining; and *(2)* the adoption of a proper publicity method by every company. Every piece of information likely to be of interest to the general body of shareholders should be issued, and issued promptly, with an explanatory note attached, if necessary.

In the last ten years there has certainly been an improvement as regards the treatment of shareholders by those responsible for the control of mining companies. No doubt this is due, at any rate in part, to the fact that more mining engineers have joined the ranks of mining directors, while, as you have pointed out, the status of the professional mining engineer is now much stronger than it was. It is only fair to add that the majority of the better known companies, if they have not quite a perfect publicity method, leave little to be desired in this respect. There will still be room for improvement, however, so long as there remain any backsliders who, while they may not make glaring misstatements, do not tell the whole truth.

J. LEVITT GALLARD.

France, January 25.

Tin Dressing Problems.

The Editor:

Sir—Under the above heading in your December issue, there are one or two statements relative to myself which I trust you will pardon my saying are scarcely correct or in accord with the facts of the case.

You state "thus Mr. Martin worked solely on the round frame," whereas the first commercial machines erected on a local mine were not on the round-frame principle, but of a totally different nature. The difficulty (if such it be) to which you refer in the flat glass segments causing a guttering at the junctions did not obtain in the round frame which was first erected, with curved segments so arranged as to form a perfect section of a cone. A fuller acquaintance with the salient facts of this matter will, I am of opinion, clearly demonstrate that a guttering causing a little loss when one type of flute is employed, ceases to be harmful with a different fluting of a capacity therein to allow of lateral packing of any mineral at first finding its way into such guttering.

Your further remark that older patents exist which make it necessary for me to confine my claim to one particular mode of application is not in accord with either the contents of the numerous patents which have been granted me in the main countries of the world, nor with the opinions of most eminent patent authorities.

To one who like myself has been engaged in patenting over a long period of years, it is well known that any invention or improvement of value is closely linked up with possible litigation, but the latter even is scarcely as tedious as the evolutionary stages which all improvements relative to mineral recovery apparently have to pass through.

W. MORLEY MARTIN.

Redruth, January 12.

Laterite.

The Editor:

Sir—Living as I do within a few hundred yards of laterite deposits, both ancient and in course of formation, I have read with much interest Mr. Morrow Campbell's able articles on laterite in the Magazine. With the view that laterite does not form on steep slopes I am in agreement; my seeming dissent from this proposition, to which Mr. Campbell refers, is due to my using the term "steep" in a relative sense. That is to say, I referred to slopes steep enough to cause surprise at their being constantly water-logged, not such, however, as to be considered steep from the point of view of a climb. It seems to me that the most important point in connection with laterization is the fact that it only takes place in ground which is alternately dry and water-logged, and in regard to this I may perhaps offer the criticism that Mr. Campbell's use of the term "vadose water-level" is liable to cause some confusion. Water-level or vadose water-level generally implies the permanent water-level met with in sinking, usually about 100 ft. in this country. The saturated sub-soil in which laterite forms is usually only a foot or so below the grass roots. There is an excellent example in a valley within half a mile of my own house, where a well has been sunk 120 ft. before reaching a permanent water supply, whereas laterite is forming just below ground, and there are pools of surface water persisting throughout good rainy seasons. The most novel point in Mr. Campbell's valuable papers is probably his interesting exposition of the origin of alumina-rich laterites. This serves among other things to show the untenable character of the attempt made in some quarters to draw a hard and fast line between laterite and bauxite and also the impossibility of restricting the term laterite to alumina-rich hydrates as opposed to those rich in iron.

F. P. MENNELL.

Bulawayo, Rhodesia,
December 15.

Laterite.

The Editor:

Sir—In reading your issue of November last I was much interested in the final article on Laterite by Mr. J. Morrow Campbell. I was a member of the first English expedition into the French Soudan in 1901–2, on which occasion we traced the laterites all the way from headwaters of the Sénégal almost unbroken right through to Bondukoo on the Ivory Coast. I also visited the French Guinea and the Wassulu country in 1903, in some cases finding laterite 40 ft. thick and being much puzzled, as were other members of the expedition, to account for its occurrence. I might add that I saw built a furnace which within 10 hours yielded from this same laterite an iron pig of 10 lb.; at least it was the same laterite as far as we were concerned, and one member of the party was a leading geologist of his day. I feel sure that further study of the West African laterites will produce large iron ore resources.

S. F. G. WHITE.
A.I.M.M., Captain R.E.

On Active Service, January 11.

NEWS LETTERS.

BULAWAYO.

November 23.

RHODESIA IN WAR TIME.—Rhodesia has probably suffered less from the effects of the war than any other British colony. She has contributed a very high proportion of her male adults, but this could only be expected, as in a young colony a large percentage of the population are of suitable age and physique. As an engineer continually travelling around the mines, I am impressed not so much with the difficulties and increased cost of working due to war conditions, as with the remarkable resourcefulness shown by the operators in avoiding these. This statement should not be read as indicating that costs have not increased, or that the difficulties due to war conditions are not very great, but rather as indicating that matters might have been much worse had the inventive genius of the operators been idle. The Munitions and Resources Committee of Rhodesia, of whom J. G. McDonald is the Chairman and with whom most of the leading technical men are associated, has done and is still doing much useful work of national importance. When originally formed it was called a Munitions Committee, but its energies are now almost entirely confined to developing and exploiting the natural resources of the country and assisting the producers in dilemmas arising from their inability to procure standard articles necessary in their business. Any new invention or new departure from established practice developed, or in process of development, on any mine or other organization is immediately investigated by the committee, and the country is kept well informed through the public press and the committee's publication of the progress and the commercial possibilities thereof. The possibilities of the local manufacture of suitable articles hitherto imported, and the question of the economic exploitation of the rarer minerals, are investigated by the committee. Throughout the country prospectors and intending manufacturers are constantly receiving advice which, owing to the status of the advisers, is generally sound. A number of products are now being obtained direct or manufactured locally to take the place of the pre-war imported articles. By this means, in most cases a direct reduction in cost is obtained, and in some cases this reduction makes the article cheaper than when imported before the war. Local pebbles or mine rock are now used almost exclusively in tube-mills in place of the imported pebbles which are now unprocurable. Lead nitrate made from local lead is used exclusively in place of the old imported lead acetate. Lead nitrate has a slightly higher value in lead than lead acetate, and on that account precipitates more sulphur in cyanide solution proportionate to the weight used.

Successful experiments have been made on the Falcon mine in connection with the manufacture of copper plate, calcium carbide, and chloride of lime, and I understand this mine is supplying its own requirements in connection with the last two articles. Experiments have also been conducted with regard to the local manufacture of flotation oil, but it is not known if any success was obtained. Experiments were carried out on the Globe & Phœnix in connection with the use of slimed charcoal for precipitating gold from cyanide solution. This process was developed by K. B. Moore and H. R. Edmands on the Yuanmi mine in West Australia. There they used a vacuum adaptation of the Merrill zinc dust process, and I understand the process is still in successful use. On the Globe & Phœnix the ordinary filter-press principle was employed. The results were quite successful from a technical point of view, but the savings indicated did not warrant scrapping an established plant. It is probable that more will be heard of this process in Rhodesia, as it appears to be especially suited to the requirements of the small worker. The consumption of charcoal appeared to be about 0·40 lb. per ton of solution precipitated.

The problem of keeping up the supply of cattle-dip is acute, and white arsenic is almost unobtainable. John Buchanan, in association with the writer's firm and others, is erecting furnaces to produce arsenious oxide from the high-grade mispickel ores of the Penalonga Valley, and intends later to make dip. The high price of copper has caused a number of small properties to be opened up in various parts of the country. In the Northern Lomagundi district especially there is much promise of a permanent industry being established. At present all these small mines ship their picked ore to the Falcon, and the Government would be well advised if they erected a small customs smelter on Australian lines to help develop the Lomagundi mines. An important chrome deposit has recently been located in the Umvukwe, some 60 miles from Salisbury. The ore is said to average 54% chromic acid. The Shabani and Mashaba asbestos fields are opening up well, but the production of asbestos and of chrome from Selukwe is regulated according to available shipping from Beira.

Barite is being produced at Que Que; it is said to exist in large quantities. A local fertilizer company has commenced turning out high-grade fertilizers in Salisbury. A company has been formed to erect meat-canning works at Odzi. Locally made cement, fire-bricks, and fire-clay have satisfactorily taken the place of imported articles. Good grade assay pots and other material are being made in the Union. Scheelite is being produced in the Umtali district, and wolfram from near Bulawayo, but only in small quantities.

It is interesting to note the many ingenious devices used by the small worker to enable him to "cut his coat to the measure of the cloth available." It is common to see filter bottoms for sand-leaching tanks made as follows: About 8 in. of loose rock, crushed to pass a 2 in. ring, is placed on the bottom of the vat. A layer of finer stone is placed on top of this; then about 3 in. of clean coarse sand. Shovelling slats placed 4 in. apart complete the bottom, which gives excellent results, and take the place of the conventional coco-matting canvas. A large sulphuric acid drum, lined with firebrick placed vertically, and having attached a small Buffalo forge or other blower, is often used for smelting gold slime or for making assay-furnaces. No stack is needed. The furnace will take a 70 smelting pot or 12 G Battersea Morgan assay pots. The furnace is self contained, readily portable, and very rapid.

Slime is generally treated by the small worker by leaching methods. In the dry season the slime is picked up with Kaffir hoes and when quite dry is mixed with a small percentage of sand and leached in shallow tanks. When quite dry ordinary slime entirely alters with regard to its physical characteristics. Dry slime absorbs water, and disintegrates like caustic lime. Mixed with a little sand, this dry slime makes a suitable leaching mixture if leached in about a 24 in. column. The plant required is cheap, pumping is done by Challenge pumps operated by hand, and the costs figure out at about 4 shillings per ton with the present price of chemicals. A drag belt classifier is generally used by the small worker to separate his sand and slime. This is situated at the foot of his battery plate; it is home made and consumes a minimum of power and maintenance cost. It delivers to a truck a clean sand containing 10 to 12% of moisture, and this is leached direct.

The gold miner in Rhodesia is handicapped by the fact that the ancient miners picked the eyes out of nearly every mine in the country. Very few mines over 5 dwt. were left untouched by the ancients. The present-day operator is very soon faced with water and sulphide ore. Ore-bodies abound and all sorts of refractory elements such as antimony, arsenic, oopper, pyrrhotite, etc., are met with. In some districts such as Shagari and Makaha a central concentrate-roasting plant would be a blessing. This would be fed perhaps from small mines fitted with mechanical concentrators, followed by a cheap flotation apparatus of the cascade type. At present the Falcon operates the only flotation plant in Rhodesia. This is a copper-gold proposition, and the concentrate is smelted. Experiments carried out by the writer's firm on floating refractory gold ores have not as yet indicated ultimate success, taking all the factors into consideration. The development and equipment of big properties has almost ceased owing to the cost of plant, although the Gold Fields have been recently conducting metallurgical tests on the treatment of the Arcturus and Asp ores. These were two large gold mines developed in pre-war days.

Such things as pipes, rails, etc., now bring abnormal prices, and the country is practically living on second-hand accumulated stocks. Many old steel vats are being dismantled and sent to the Rand or the Congo to be turned into mine trucks, etc. Copper wire for electrical purposes is sold at 4s. 6d. per pound.

W. B. Blyth.

KALGOORLIE.

October 24.

Transcontinental Railway. — The mail carrying this letter will be the first to go across the Continent of Australia. The linking-up of West Australia with the eastern States has been the life-long ambition of our Grand Old Man, Sir John Forrest, who has fought for it for many years. It is fitting, therefore, that as he—when but a young man—led his exploring party from Perth to Adelaide, so now as a consummation of his many public works, he should travel on the first through train from East to West.

Labour.—Coincident with the opening of this line, is the news that the strike of coal miners, waterside workers, and seamen, which has practically isolated West Australia for many weeks, has been declared off, and the strikers return to work on the employers' terms. That is to say, the members of the various Unions who have been on strike will work with free labourers, who came to the rescue of the Government, and enabled sufficient transport to be carried on to provide food. The de-registration of many Unions, and the repeal of the preference-to-unionists clause, will, we trust, pave the way for more freedom for good men to improve their standing and earn more wages, rather than under the Union standard by which the good men are only allowed to do as much work as the lazy or incompetent. This slowing-down process has been growing in all industries; and in mining, especially of coal, the efficiency per man has been steadily decreasing. The employers on their part must play the game, and recognize good work by payment by results. It is pleasing to state that on most of the mines this is so, but there are still managers who will not realize the economy of this method, and who pay all of their men the minimum wage, irrespective of worth. If the employers of this type and the employees who do as little work as possible can be broadened or eliminated, strikes such as we have been experiencing, at a cost of millions of pounds, will give way to real conciliation and arbitration.

Arbitration Court. — The Federal Arbitration Court will be held this week at Kalgoorlie, to deal with some difficulties which have arisen as to the interpretation of an award of the Court given to the Engine Drivers' Union. The plaint of the Miners' Union for an increase in wages and alteration of conditions will be heard by the Court. The men claim that owing to the greatly increased price of living since the war started, it is impossible for them to live on the present wage. The companies reply that if any increase be given several of the mines, which are now only just paying their way or losing money, will have to shut down, thus throwing several thousand men out of work.

Westonia. — Another mine at Westonia has become a producer. The Edna May Consolidated has started its 10 stamp mill. Their lode is stated to be worth over 40s. for a width of 52 ft., and having a length of 130 ft. If this value be correct, and should it continue in depth, it will add considerably to the possibilities of this field. The Edna May Deep has a shoot of ore at the 560 ft. level, over 100 ft. in length, and all the ore taken out over a width of 14 ft. has averaged 128s. per ton. A winze is being sunk below this level to see whether the shaft should be continued vertically or converted into an underlie shaft following the lode.

The Edna May Company is now developing its 480 ft. level, at which depth the lode underlies into the Deep Levels. It is unfortunate that these two mines were not amalgamated, thus doing away with the duplication of shafts, plant, management, and board of directors.

NEVORIA. — The Great Boulder No. 1 company is reported to have secured an option on a new find at Nevoria, which is about 30 miles south of Southern Cross. The lodes in this district are ferruginous quartz formations, which on the surface carry good-grade ore over big widths, but in those already opened the gold contents rapidly decrease with depth. The point to look for is the country rock (quartz dolerite) in which lodes are likely to continue downward. Mr. Doolette, of the Bullfinch company, is also investigating some leases on the same line of lode.

KALGOORLIE. — What might have been the cause of a serious accident occurred on the Great Boulder mine, due to earth tremors which were felt along the belt of greenstone country for some twelve miles. The resulting fall of ground in the mine buried one man, and caused the suspension of operations in that portion of the stopes for a time. The State Mining Engineer was sent to investigate the cause of the fall, and Professor Woolnough, who occupies the chair of geology at the University of Western Australia, looked into the geological aspect. The latter considers it a far reaching earth movement, but thinks that mining operations were probably a contributing factor in accelerating this. However, the mining practice adopted is such as to remove all fear of wholesale disaster.

It is a long time since a new development has been reported on any of the mines on the Golden Mile; it is therefore cheering to note that in cross-cutting east at the No. 12 level, the South Kalgurli Consolidated struck a lode which so far as proved averages 70s. over a width of 60 in.

BASE METALS. — Considerable attention is being paid to the base metal mines of this State. At Ilgarary, which is 200 miles north of Meekatharra, consignments of high-grade (40 to 50%) copper ore are being sent to New South Wales to be smelted, whenever boats are available. Ravensthorpe district has its own smelter and has a regular output of copper and gold. The Northampton district keeps the smelters of the Fremantle Trading Company going in lead. Most of the supplies are obtained from the company's own mines at Baddera and Narra Terra, but other old mines are being re-opened and worked by tributers, who send a product of about 70% lead, either in the form of concentrate or in picked crude galena.

GRAPHITE.—The representative of one of the big English crucible firms has recently been visiting the Esperance district to inspect the graphite deposits there, and says that their flaking quality is good. Seeing that a concentrate containing 80% carbon is worth from £20 to £25 per ton at Fremantle, this opinion is encouraging local syndicates and companies to develop these deposits.

SOLDIERS AS PROSPECTORS.—The action of Sir George P. Doolette in financing a returned wounded soldier to prospect some likely country that the latter knows of is heartily applauded here. There will be many miners physically unable to return to their work in the mines, and if they could be financed to enable them to go prospecting on terms by which they would retain a quarter or third interest in anything payable found, it would possibly be the means of discovering a new goldfield. West Australia abounds in useful minerals also, and the attraction of making a fortune will lure many British soldiers, who will not be able to settle down to their indoor occupations again, after their outdoor life at the front.

CAMBORNE.

TEHIDY MINERAL RIGHTS.—The purchase by Dolcoath Mine, Ltd., and East Pool & Agar, Ltd., jointly of the Tehidy mineral rights, extending over an area of nearly 9,000 acres, is a transaction which may rightly be regarded as one of great value and importance not only to the two companies concerned, but to Cornish mine interests generally. It foreshadows post-war activity in the exploitation of entirely unwrought and partly unwrought ground in the heart of the famous Camborne mining district; the embargo by the Treasury on the provision of new capital is likely to hold up any development work, except testing by diamond-drill, until after the close of the war. It is one of those many inexplicable stupidities that puzzle business men to-day, that while one Government department is pressing for an increased output of tin, another department vetoes the provision of capital which would, in many cases, enable such an increase to be made.

The Tehidy estate was purchased from A. F. Basset about 2½ years ago by Messrs. Bond and Edwards, and several attempts have been made since on behalf of the owners by Mr. Herbert Thomas (of the *Cornish Post*) to induce the mines concerned to buy their mineral rights, but without success. This was mainly because the price required was too high, and partly because of the depressed state of the industry. However, conditions are now vastly different; Cornish mine shares are one of the bright spots in the base-metal section of the Stock Exchange; and the price demanded was reduced to £90,000, of which two-thirds is to be provided by Dolcoath, and one-third by East Pool & Agar. The agreement in connection with this deal provides that Dolcoath will take over not only the mining rights under the lease of the Dolcoath mine, but also of the adjoining properties of Cook's Kitchen and West Stray Park; while on the other hand, East Pool & Agar will take over the mineral rights of East Pool mine, together with those of Carn Brea, Burncoose, and Wheal Tehidy. The income from the remainder of the mineral rights, which include South Crofty and several tin streams, will be divided in the same proportion as the purchase money. The net income by way of mineral royalties from the whole estate in 1917 amounted to £16,335, but the elimination of Dolcoath and East Pool reduces this to £4,893. It would not surprise me to hear that the South Crofty company had opened up negotiations for the purchase of the setts now held by the company under lease; it would appear to be sound policy to do so while the company's position financially is so strong, and doubtless the price would not be unreasonable.

The credit for this important deal is mainly due to the Messrs. C. V. Thomas and Oliver Wethered, and to a lesser extent to Messrs. Rogers, Moreing, and Holman, while the zeal of Mr. Herbert Thomas, the proprietor and editor of the *Cornish Post*, must not be overlooked.

DOLCOATH. — To provide its two-third share (£60,000) of the purchase consideration for the Tehidy mineral rights and also additional working capital, this company is, with the consent of the Treasury, issuing debentures to the extent of £75,000, which will be secured by a floating charge on the company's undertaking, and it is provided that no other charge may be created in advance or *pari passu* with this issue.

These debentures will carry interest at 6% per annum free of income tax, will have a currency of 10 years, and then be redeemable *pro rata* by five equal annual instalments. The subscribers of the stock will also receive an income-participating certificate entitling them to have, in addition to the interest on the debentures, a *pro rata* share of the profits made by the company. This issue has been underwritten, and in view of the attractive terms of these debentures, it is anticipated that they will be over-subscribed by the shareholders.

The royalties paid by the company for the three years ended December 31, 1916, averaged slightly over £7,700 per annum. In future, no royalities will be paid, but, in substitution, there will be the debenture interest, which, with tax at 5s. in the £, will amount to £5,600 per annum. Against this, can be put two-thirds of the present income of the estate, or say £3,262, which will probably be substantially increased as other parts of the estate are developed.

Tehidy mineral rights deal, and in future will pay no dues on mineral produced from the East Pool section of the property. Unfortunately, the Rogers lode is situated in the Agar section, which is owned by Viscount Clifden, so that royalties on the main portion of the company's output will still be payable. However, it was a far-sighted action to allocate part of the company's cash reserve for this transaction, and although the immediate benefit may not apparently be so tangible as in the case of Dolcoath, the acquisition of the adjoining setts of Carn Brea, Burncoose, and Wheal Tehidy will provide much scope for development, while, too, of course, the company will hold a one-third interest in the residue of the Tehidy estate, covering a large extent of mineralized ground, which doubtless will be developed by separate companies after the war.

As foreshadowed in the last issue, at the request of the Controller of the Department for the Development

The Mining District between Camborne, Truro, and Falmouth.

Shareholders in the company generally are highly pleased at this bold stroke on the part of the board, and with the additional capital provided by this issue, the vigorous development of the mine may be anticipated so soon as the necessary labour is available. No official information is available as to the value and width of the ore-body intersected by the diamond-drill in the bottom of the mine, but it is anticipated that the manager (Mr. R. A. Thomas), who is now away recuperating his health, will have something encouraging to say about this discovery at the half-yearly meeting next month.

For six months ended December 31 last, 34,540 tons of ore was crushed, producing 468 tons of tin concentrate, or an average recovery of 30·32 lb. per ton, as compared with 31·85 lb. for the previous six months. The value of the tin sales was £67,807, as against £62,889, while also 24 tons of crude arsenic was sold, realizing £2,191.

East Pool & Agar, Ltd.—As referred to previously, this company has taken a one-third share in the

of Mineral Resources, it has been decided to increase substantially the production of tin concentrate, and it is hoped to bring this up to 140 tons per month, which will make the company the Empire's largest producer of tin with the exception of the Pahang. This will be brought about by mining a higher percentage of ore from the Rogers lode. No announcement has been made as to the arrangement made with the Government respecting the operation of the Excess Profits Duty on the greatly enhanced profit which will necessarily be made, but I venture to express the belief that the shareholders will have no reason to be dissatisfied, and will in due course receive the reward for backing their faith in the property when the present company was formed.

Excess Profits Duty.—The appeal of the Cornish Chamber of Mines for an increased percentage allowance for the Cornish mining industry is to be heard by the Board of Referees this month, and it is to be hoped that the result will be favourable, for the provision of capital for new enterprises depends largely on whether the Board adopts a sympathetic attitude or not. The labour shortage and the enormous increase in the cost of coal, and all other essential materials, more than off-sets the higher price realized for the products of the mines, and it must be remembered, too, that for a long period after the outbreak of war, the price of tin was lower than the pre-war price. It would obviously have been better to have submitted the appeal at that time, but the companies generally did not then appear to appreciate the importance of this matter to the industry at large. It is to be hoped that the Department for the Development of Mineral Resources, so ably presided over by Sir Lionel Phillips, will vigorously support the Chamber of Mines in this important matter.

BELGIAN LABOUR. — There appears to be some possibility of a supply of Belgian miners being available for work in the mines, and in view of the great shortage of local miners, it is to be hoped that they will materialize. Without additional miners, no very substantial increase in the output of tin, outside East Pool & Agar, can be expected, and while it would have been far preferable to have men in the lower medical categories returned from the Army, Belgian labour, if efficient, should be a fair substitute. There will be difficulties in feeding and housing any considerable number of these men, and of course, the language difficulty will have to be overcome. I do not anticipate any opposition on the part of local labour, which, it will be recalled, some years ago, prevented the experiment of Italian labour at Levant being a success.

BASSET.—The average grade of the ore milled has again been falling for the past few months, the last issued monthly report showing a recovery of 36 lb. per ton against 45 lb. in October. Basset is a difficult proposition to handle in these times, and Capt. William Jopling, who has succeeded Capt. William James as manager, has a hard row to hoe. He is, on the one hand, up against a scarcity of miners with consequent small output, and on the other, abnormally high standing charges due to the heavy incoming water.

GRENVILLE.—There is very little improvement to be recorded at this mine, and water troubles, due largely to inefficient pumping plant, continue to retard development in the bottom of the mine. It was suggested in this Magazine some years ago that it would well repay the management to call in a mechanical engineer of high reputation and experience in Cornish pumping plants, and that opinion still holds good. There is some talk of removing the office of the company to Cornwall, and opinion is divided as to whether this would be either wise or economical.

PERSONAL.

H. W. ALDRICH, lately superintendent of the Ladysmith Smelting Corporation, has joined the staff of the Anaconda Copper Mining Company.

DR. RAYMOND F. BACON, of the University of Pittsburgh, is in charge of the chemical work for the American armies in Europe.

EDGAR BONDS has returned from the Taquah mine, West Africa.

W. SINCLAIR BROWN has resigned as chief metallurgist at Redjang Lebong, Sumatra, and is returning to England via San Francisco.

GEORGE B. BUTTERWORTH has returned to the mines of the South American Copper Syndicate, Venezuela, after a trip to the United States.

PROFESSOR W. BOYD DAWKINS has been awarded the Prestwich Medal of the Geological Society.

J. A. DENNISON has returned from South Africa.

H. C. DUDLEY, of Duluth, has been appointed Captain in the U.S. Engineer Officers Reserve Corps and has been assigned to the 36th Regiment of Engineers.

SIR JOHN FORREST, the distinguished West Australian explorer, has been made a peer. He is the first Australian member of the House of Lords.

JAMES GRAY, who has been managing a coal mine in Tasmania, expects to return to British Columbia shortly.

R. T. HANCOCK is here from Nigeria.

A. A. HARRIS has returned from Bolivia.

E. C. B. HEDEN, recently a member of the staff of the Charters Towers School of Mines, is now with the Mount Elliott company.

A. B. W. HODGES, who was for some years manager for the Granby Consolidated, British Columbia, is now a member of the Sulphur Committee of the United States War Industries Board.

D. C. JACKLING is in charge of construction work in connection with explosives plants for the United States Government.

DR. H. I. JENSEN is temporarily with the Queensland Geological Survey.

SIR ALFRED KEOGH is retiring from the position of Director-General of the Army Medical Services, a post which he has held since the beginning of the war, and is resuming his duties as Rector of the Imperial College of Science and Technology.

E. E. MCCARTHY has been appointed manager for the Yukon Gold Co., at Dawson.

JAMES PARK has returned to West Africa.

CAPTAIN H. G. PAYNE, Deputy Assistant Adjutant of Labour in France, has been awarded the D.S.O.

The Perkin Medal for 1918 has been awarded to AUGUSTE J. ROSSI in recognition of his work on titanium.

N. I. TRUSCHKOFF has returned to Russia by way of the United States and Japan.

J. B. TYRRELL has been nominated for the presidency of the Canadian Mining Institute. He has been awarded the Murchison Medal of the Geological Society of London. He left Liverpool on his return to Canada on January 27.

We regret to announce the death of A. C. PERKINS, the manager of the Malayan Tin Dredging Co., Ltd. He was on a holiday trip to Japan, when he was struck down by an attack of small-pox, and died in Tokyo Hospital on December 23.

JOHN SCUDAMORE SELLON, whose death at the age of 81 took place on January 18 in London, was born in 1836, fifth son of Captain William Baker Sellon, R.N. At an early age he joined the well-known business house of Johnson, Matthey & Co., Assayers and Refiners to the Bank of England and Royal Mint, Metallurgists, &c., founded by his uncle, Percival Norton Johnson, in 1822. He played a prominent part in the researches and industrial developments connected with the platinum and other groups of rarer metals, with which the name of his firm is closely associated; indeed the now numerous and important commercial applications of platinum and its allied metals may be said to be chiefly due to the initiative and efforts of himself and his co-workers, George and Edward Matthey. During the concluding quarter of last century he also took an active share, both in the fields of technical discovery and industrial development in the then new sphere of electrical engineering, and was associated with Faure, Brush, Swan, Lane-Fox, Volckmar, and others in their early work on electric lighting and storage.

METAL MARKETS.

The Non-Ferrous Metals Act, to which reference was made in our December issue, was passed early this month. This Act provides that transactions in non-ferrous metals and minerals shall be, in certain ways, under government supervision, the object being to obviate the possibility of enemy control.

COPPER.—No alteration has yet been made in the official prices, which still stand at £110–£110 10s. for standard, and £125–£121 for electrolytic. In America the official basis has been fixed at 23½ cents for the next four months. It is reported that production in South America is being hampered by the increased cost of labour, supplies, and adverse exchange. It is gratifying, however, to learn that the United States output shows an increase, and that the exports for 1917 are nearly 30% higher than the highest pre-war record, and amount to 50% of the country's output. This seems to rule out any possibility of a shortage in the metal, especially as the manufacture of non-essentials will be largely diminished through the diversion of labour to military necessities. With the prospects of better weather ahead a still higher output may be confidently looked for.

Average prices of cash standard copper: January 1918, £110. 5s.; December 1917, £110. 5s.; January 1917, £131. 16s. 9d.

TIN.—Prices have now recovered from the low panic level produced by the Government restrictions, and the market has steadied at about £295 to £300. Straits metal in London is in demand and commands a premium over standard of 30s. to £2. The scarcity apparently arises from the fact that some licences for shipment have been granted. The backwardation for spot tin over three-months has been reduced to about 30s., the latest official quotations being £300. 15s. cash and £229. 10s. three months. The American position is not quite clear, but spot sales are reported at 80 cents; for shipment deals have been put through at considerably lower. Batavia seems more ready for business, but the sales are being made direct to America, and American buyers are also purchasing direct in the Straits. There is an active trade in English, many makers being so well booked that they cannot take orders for reasonably early delivery. Home trade is spasmodically active and full prices are paid.

Average prices of cash standard tin: January 1918, £293. 6s. 2d.; December 1917, £298. 10s. 3d.; January 1917, £186. 6s. 4d.

LEAD.—There is no change in price to record in this country. The official quotations are £29. 10s. to £28. 10s. net, the gross equivalents being £30. 10s. 5d. to £29. 9s. 9d. There is still a great scarcity of metal. In America the market has been firm, large offerings have been bought up, and buyers of spot are reported at 7·12½ cents.

Average prices of soft foreign lead: January 1918, £29; December 1917, £30; January 1917, £30.

SPELTER.—The market remains steady here at £54–£50. In America a better feeling has been established with a moderate inquiry for spot material, the price of which advanced to 7·75 cents to 8 cents, the same price being paid for March. The latest reports indicate a steady business doing.

Average prices of good ordinary brands: January 1918, £52; December 1917, £52: January 1917 £48. 8s. 3d.

ZINC DUST.—In the absence of supplies of Australian high-grade dust and the English production being practically all absorbed for Government purposes, consumers have had to cover their requirements as best they could by picking up the small lots of Japanese and French brands offering. Very little French and Japanese zinc dust is reaching England and the shortage is causing much concern.

ALUMINIUM.—£225 per ton. NICKEL.—£220 per ton.

QUICKSILVER.—£22 per flask of 75 lb.

BISMUTH.—12s. 6d. per lb. CADMIUM.—8s. per lb.

PLATINUM.—New 290s. per oz.; scrap 260s.

MOLYBDENITE.—105s. per unit, 90% MoS_2.

WOLFRAM.—60s. per unit, 70% WO_3.

SILVER.—The price has been very firm for most of the past month, and the scarcity of supplies causes anxiety to the various Governments. In England, 5s. notes are ready for circulation if necessary.

PRICES OF CHEMICALS. February 12.

Owing to the war, buyers outside the controlled firms have a difficulty in securing supplies of many chemicals, and the prices they pay are often much higher than those quoted below.

		£	s.	d.
Alum	per ton	17	10	0
Alumina, Sulphate of	,,	18	0	0
Ammonia, Anhydrous	per lb.		1	10
,, 0·880 solution	per ton	33	10	0
,, Chloride of, grey	per cwt.	2	7	0
,, ,, ,, pure	,,	4	0	0
,, Nitrate of	per ton	65	0	0
,, Phosphate of	,,	110	0	0
,, Sulphate of	,,	15	10	0
Arsenic, White	,,	145	0	0
Barium Sulphate	,,	9	0	0
Bleaching Powder, 35% Cl.	,,	18	0	0
Borax	,,	37	0	0
Copper, Sulphate of	,,	68	0	0
Cyanide of Potassium, 98%	per lb.		1	0
,, ,, Sodium, 100%	,,			10
Hydrofluoric Acid	,,			7
Iodine	,,		14	0
Iron, Sulphate of	per ton	12	0	0
Lead, Acetate of, white	,,	145	0	0
,, Nitrate of	,,	65	0	0
,, Oxide of, Litharge	,,	42	0	0
,, White	,,	46	0	0
Magnesite, Calcined	,,	14	0	0
Magnesium Sulphate	,,	11	0	0
Phosphoric Acid	per lb.		1	4
Potassium Carbonate	per ton	190	0	0
,, Chlorate	per lb.		2	3
,, Chloride 80%	per ton	60	0	0
,, Hydrate, (Caustic) 90%	,,	400	0	0
,, Nitrate	,,	70	0	0
,, Permanganate	per lb.		15	0
,, Prussiate, Yellow	,,		3	6
,, Sulphate, 90%	per ton	65	0	0
Sodium Metal	per lb.		1	8
,, Acetate	per ton	115	0	0
,, Bicarbonate	,,	8	10	0
,, Carbonate (Soda Ash)	,,	7	0	0
,, ,, (Crystals)	,,	4	5	0
,, Hydrate, 76%	,,	26	0	0
,, Hyposulphite	,,	42	0	0
,, Nitrate, 95%	,,	27	0	0
,, Phosphate	,,	45	0	0
,, Silicate	,,	7	0	0
,, Sulphate (Salt-cake)	,,	2	12	6
,, ,, (Glauber's Salts)	,,	3	10	0
,, Sulphide	,,	37	0	0
Sulphur, Roll	,,	21	0	0
,, Flowers	,,	23	0	0
Sulphuric Acid, non-arsenical 144°T.	,,	4	5	0
,, non-arsenical 95%	,,	7	0	0
Superphosphate of Lime, 18%	,,	5	0	0

STATISTICS.

Production of Gold in the Transvaal.

	Rand	Elsewhere	Total	Value
	Oz.	Oz.	Oz.	£
Year 1912	8,753,563	370,731	9,124,299	38,757,560
Year 1913	8,430,998	363,826	8,794,824	37,358,040
Year 1914	8,033,567	344,570	8,378,139	35,588,075
Year 1915	8,772,919	320,752	9,073,671	38,627,461
Year 1916	8,971,359	324,179	9,295,538	39,484,934
January 1917	756,997	25,637	782,634	3,324,418
February	696,955	24,366	721,321	3,063,976
March	760,598	26,496	787,094	3,343,363
April	717,598	25,180	742,778	3,155,121
May	753,531	26,034	779,385	3,310,618
June	732,799	26,925	759,724	3,227,101
July	731,848	25,991	757,839	3,219,094
August	731,405	25,253	756,658	3,214,079
September	712,881	25,350	738,231	3,135,807
October	724,846	26,444	751,290	3,191,279
November	698,271	24,568	722,839	3,070 426
December	697,137	25,282	722,419	3,068,639
Year 1917	8,714,866	307,527	9,022,493	38,323,921
January, 1918	694,121	19,991	714,182	3,033,653

Natives Employed in the Transvaal Mines.

	Gold mines	Coal mines	Diamond mines	Total
January 31, 1917	188,624	11,611	5,591	205,826
February 28	191,095	11,568	6,268	208,931
March 31	190,028	11,494	6,620	208,142
April 30	185,975	11,435	6,314	203,724
May 31	180,168	11,432	5,805	197,405
June 30	175,727	11,258	5,369	192,354
July 31	171,653	11,381	5,223	188,257
August 31	170,817	11,401	5,028	187,246
September 30	171,334	11,601	4,791	187,726
October 31	170,531	11,841	4,620	186,792
November 30	169,083	11,633	4,620	185,336
December 31	172,740	11,695	4,593	189,028
January 31, 1918	176,424	11,469	4,715	192,608

Cost and Profit on the Rand.

Compiled from official statistics published by the Transvaal Chamber of Mines. The profit available for dividends is about 60% of the working profit.

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
Year 1912	25,486,361	29 2	19 3	9 11	12,678,095
Year 1913	25,628,432	27 9	17 11	9 6	12,189,105
Year 1914	25,701,954	26 6	17 1	9 0	11,553,697
Year 1915	28,314,539	26 3	17 5	8 5	11,931,062
November 1916	2,389,056	26 9	18 2	8 2	980,387
December	2,349,191	26 10	18 2	8 4	977,481
January 1917	2,337,066	26 10	18 8	7 11	941,520
February	2,153,691	27 3	19 2	7 10	841,259
March	2,430,590	26 7	19 0	7 4	879,351
April	2,235,833	27 2	19 2	7 8	857,710
May	2,405,855	26 4	18 7	7 5	887,527
June	2,288,426	26 11	19 2	7 7	867,639
July	2,294,668	26 11	19 0	7 7	869,577
August	2,301,892	26 9	19 0	7 6	859,517
September	2,195,884	27 5	19 4	7 9	848,096
October	2,280,461	26 10	19 5	7 2	814,211
November	2,156,814	27 4	19 11	7 2	775,502

Production of Gold in Rhodesia and West Africa.

	Rhodesia.		West Africa.	
	1916	1917	1916	1917
	£	£	£	£
January	318,586	296,113	140,579	131,665
February	313,769	289,734	137,739	104,892
March	335,368	300,183	150,987	158,727
April	339,386	297,977	135,976	123,825
May	323,783	299,271	132,976	121,104
June	333,070	302,195	127,107	114,489
July	322,365	288,731	128,574	142,017
August	338,001	294,359	125,143	130,278
September	322,035	291,367	127,138	127,168
October	325,608	289,978	132,577	126,295
November	317,135	275,829	130,101	126,915
December	306,205	270,616	146,409	122,602
Total	3,895,311	3,495,391	1,615,356	1,529,977

West Australian Gold Statistics.

	Reported for Export oz.	Delivered to Mint oz.	Total oz.	Total value £
January 1917	*	83,962	*	*
February	*	81,810	*	*
March	*	76,171	*	*
April	*	82,144	*	*
May	*	78,165	*	*
June	*	82,600	*	*
July	*	81,166	*	*
August	*	80,181	*	*
September	*	81,761	*	*
October	*	73,901	*	*
November	*	80,642	*	*
December	*	78,793	*	*
January, 1918	*	73,703	*	*

* By direction of the Federal Government the export figures will not be published until further notice.

Australian Gold Returns.

	Victoria.		Queensland.		New South Wales	
	1916	1917	1916	1917	1916	1917
	£	£	£	£	£	£
January	89,900	67,627	66,700	50,150	39,000	29,000
February	76,500	65,450	79,050	63,200	30,000	26,000
March	103,600	74,794	76,920	61,200	36,000	41,000
April	60,000	75,139	83,300	62,470	63,000	21,000
May	119,500	65,623	116,230	65,450	19,000	28,400
June	86,000	64,180	72,200	73,100	18,000	24,600
July	100,600	68,937	85,400	71,820	23,000	44,000
August	66,800	101,428	86,000	74,800	24,000	21,000
September	115,100	61,701	65,450	64,180	32,000	20,000
October	81,400	...	74,800	54,400	32,000	47,000
November	94,000	...	60,300	*	31,000	29,000
December	96,600	...	73,550	64,170	111,000	19,000
Total	1,090,000	713,668	939,900	...	458,000	349,000

* Figures not received.

Production of Gold in India.

	1915	1916	1917	1918
	£	£	£	£
January	201,255	192,150	190,047	176,030
February	195,970	183,264	180,904	—
March	194,350	186,475	189,618	—
April	196,747	192,208	185,835	—
May	199,786	193,604	184,874	—
June	197,447	192,469	182,426	—
July	197,056	191,404	179,660	—
August	197,984	192,784	181,005	—
September	195,952	192,330	183,630	—
October	195,531	191,502	182,924	—
November	192,714	192,298	182,388	—
December	204,590	205,164	190,852	—
Total	2,369,382	2,305,652	2,214,163	176,030

Daily London Metal Prices

Copper, Lead, Zinc, Tin, in £ per long ton. Silver in pence per standard ounce.

	Copper Standard	Copper Electrolytic	Copper Best Select'd	Soft For'n Lead	Zinc	Tin Standard	Silver
	£	£	£	£ s.	£ s.	£ s. d.	d.
Jan.							
11	110	125	123	29 10	54 0	295 0 0	45⅛
14	110	125	123	29 10	54 0	295 0 0	45⅛
15	110	125	123	29 10	54 0	298 0 0	44⅞
16	110	125	123	29 10	54 0	295 0 0	44⅞
17	110	125	123	29 10	54 0	295 0 0	44¾
18	110	125	123	29 10	54 0	295 0 0	44¾
21	110	125	123	29 10	54 0	298 0 0	44¼
22	110	125	123	29 10	54 0	300 0 0	43⅞
23	110	125	123	29 10	54 0	300 0 0	43⅞
24	110	125	123	29 10	54 0	300 0 0	43⅝
25	110	125	123	29 10	54 0	299 0 0	43⅝
28	110	125	123	29 10	54 0	299 0 0	43½
29	110	125	123	29 10	54 0	297 0 0	43½
30	110	125	123	29 10	54 0	299 0 0	43¼
31	110	125	123	29 10	54 0	298 0 0	43¼
Feb.							
1	110	125	123	29 10	54 0	296 10 0	43¼
4	110	125	123	29 10	54 0	298 15 0	43¼
5	110	125	123	29 10	54 0	299 0 0	43¼
6	110	125	123	29 10	54 0	301 0 0	43
7	110	125	123	29 10	54 0	305 0 0	43
8	110	125	123	29 10	54 0	305 0 0	43
11	110	125	123	29 10	54 0	309 0 0	42⅞

Imports of Ores and Metals into United Kingdom.

These figures now include Government imports.

* Statistics not published. Long tons.

	Year 1916	Dec. 1917	Year 1917
	Tons	Tons	Tons
Iron Ore	6,905,936	*	*
Copper Ore	34,492	*	*
,, Matte and Precipitate	43,839	3,947	28,241
,, Metal	111,412	19,267	142,778
Copper and Iron Pyrite	951,206	*	*
Tin Concentrate	33,912	*	*
,, Metal	33,646	1,519	27,143
Manganese Ore	439,509	*	*
Lead, Pig and Sheet	157,985	13,515	147,124
Zinc (spelter)	53,324	8,054	76,105
	lb.	lb.	lb.
Quicksilver	2,556,214	—	2,172,434

Exports of Copper from United States

1916	Long tons	1917	Long tons	1917	Long tons
July	35,048	January	25,540	July	38,127
August	34,700	February	24,937	August	45,304
September	28,572	March	51,246	September	30,493
October	32,712	April	79,001	October	39,115
November	21,433	May	45,241	—	38,638
December	21,438	June	39,816	—	—
Total 1916	327,277	Total	265,783	Total 1917	448,596

Outputs of Tin Mining Companies.

In Tons of Concentrate.

	Year 1916	Dec. 1917	Year 1917
	Tons	Tons	Tons
Bisichi (Nigeria)	473	31	278
Briseis (Tasmania)	467	21	237
Dolcoath (Cornwall)	1,076	60	829
East Pool (Cornwall)*	1,012	80	1,012
Gopeng (F.M S.)	1,113	73	1,039
Malayan Tin (F.M.S.)	1,104	66	828
Mongu (Nigeria)	576	50	571
Naraguta (Nigeria)	523	45	503
N. N. Bauchi (Nigeria)	578	45	550
Pahang (F.M.S.)	2,772	178	2,612
Rayfield (Nigeria)	658	65	660
Renong (Siam)	894	89	1,023
Siamese Tin (Siam)	906	70	808
South Crofty (Cornwall)*	700	59	694
Tekka-Taiping (F.M.S.)	651	29	422
Tongkah Harbour (Siam)	1,135	133	1,229
Tronoh (F.M.S.)	1,662	88	1,046

* Including Wolfram.

Stocks of Tin.

Reported by A. Strauss & Co. Long tons.

	Nov. 30, 1917	Dec. 31, 1917	Jan. 31, 1918
	Tons	Tons	Tons
Straits and Australian, Spot	3,688	2,084	3,099
Ditto, Landing and in Transit	500	1,875	400
Other Standard, Spot and Landing	703	521	498
Straits, Afloat	*4,500	*4,403	*4,085
Australian, Afloat	—	—	—
Banca, on Warrants	—	—	—
Ditto, Afloat	*2,600	*2,120	*2,300
Billiton, Spot	—	—	—
Ditto, Afloat	*300	*306	*300
Straits, Spot in Holland and Hamburg	—	—	—
Ditto, Afloat to Continent	*1,000	*500	*500
Afloat for United States	*5,727	*6,695	*7,579
Stock in America	1,592	497	767
Total Stock	20,610	19,301	19,528

* Estimated.

Shipments and Imports of Tin

Reported by A. Strauss & Co Long tons.

	Year 1916	Total 1917	Jan 1918
	Tons	Tons	Tons
Shipments from:			
Straits to U.K.	27,157	28,099	*1,500
Straits to America	25,943	24,577	*3,000
Straits to Continent	*8,487	9,290	*500
Australia to U.K.	2,537	349	—
U.K. to America	14,863	12,890	570
Imports of Bolivian Tin into Europe	15,116	19,209	1,208
Deliveries in U.K.	16,862	15,142	1,579
,, ,, Holland	943	1,714	*71

* Estimated.

Nigerian Tin Production.

In long tons of concentrate of unspecified content.

Note. These figures are taken from the monthly returns made by individual companies reporting in London, and probably represent 85% of the actual outputs.

	1912	1913	1914	1915	1916	1917
	Tons	Tons	Tons	Tons	Tons	Tons
January	204	466	485	417	531	667
February	240	427	469	358	528	646
March	247	510	502	418	547	655
April	141	430	482	444	486	555
May	144	360	480	357	536	509
June	121	321	460	373	510	473
July	140	357	432	455	506	479
August	201	406	228	438	498	551
September	196	422	289	442	535	531
October	256	480	272	511	584	566
November	340	445	283	467	679	566
December	310	478	326	533	654	608
Total	2,540	5,103	4,708	5,213	6,594	6,806

Production of Tin in Federated Malay States.

Estimated at 70% of Concentrate shipped to Smelters.
Long Tons. No figures published since June, 1917.

	1913	1914	1915	1916	1917
	Tons	Tons	Tons	Tons	Tons
January	4,121	4,983	4,395	4,316	3,558
February	3,823	3,555	3,780	3,372	2,755
March	3,562	3,839	3,653	3,696	3,286
April	4,066	4,087	3,619	3,177	3,251
May	4,319	4,135	3,823	3,729	3,413
June	3,993	4,303	4,048	3,435	3,489
July	4,245	4,582	3,544	3,517	...
August	4,620	3,591	4,046	3,732	...
September	4,379	3,623	3,932	3,636	...
October	4,409	3,908	3,797	3,681	...
November	3,976	4,085	4,059	3,635	...
December	4,614	4,351	4,071	3,945	...
	50,127	49,042	46,767	43,871	19,752

Sale of Tin Concentrate at Redruth Ticketings.

	Long tons	Value	Average
January 2, 1917	176	£17,677	£100 8 10
January 15	160¾	£16,681	£103 15 5
January 29	152	£16,095	£105 17 10
February 12	182¼	£20,649	£113 6 1
February 26	176¾	£19,700	£111 9 3
March 12	179	£20,468	£114 7 0
March 26	161¾	£19,875	£122 17 8
April 10	179	£22,024	£123 2 0
April 23	169	£21,429	£126 16 0
May 7	167	£22,248	£133 4 6
May 21	168¼	£23,772	£141 5 9
June 4	168	£22,474	£133 15 6
June 18	158½	£21,915	£138 5 4
July 2	159½	£21,661	£135 16 1
July 16	144¼	£18,896	£130 19 11
July 30	168	£23,225	£138 5 0
August 13	160¼	£21,757	£135 15 4
August 27	156½	£21,429	£136 18 6
September 10	160¼	£21,784	£135 18 9
September 24	153	£21,448	£140 3 9
October 8	160½	£22,160	£138 11 6
October 22	153	£21,712	£141 18 2
November 6	144¼	£21,063	£146 0 5
November 19	156	£24,737	£158 11 6
December 3	148	£24,609	£165 5 6
December 17	148½	£25,620	£172 10 7
December 31	151¾	£23,450	£154 10 8
Total, 1917	4,186	£561,003	£134 0 0
January 14, 1918	141	£23,563	£167 2 3
January 28	171½	£28,976	£168 19 2

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS:

RAND:	Feb. 5, 1917 £ s. d.	Feb. 5, 1918 £ s. d.
Bantjes	7 6	3 3
Brakpan	4 18 0	5 5 0
Central Mining (£8)	6 10 0	6 3 9
Cinderella	4 9	4 6
City & Suburban (£4)	1 19 6	1 3 9
City Deep	4 3 0	3 5 6
Consolidated Gold Fields	1 8 0	1 14 6
Consolidated Langlaagte	1 5 0	19 6
Consolidated Main Reef	17 3	15 0
Consolidated Mines Selection (10s).	1 0 9	1 8 3
Crown Mines (10s.)	2 18 9	2 0 0
Daggafontein	12 9	1 12 0
D. Roodepoort Deep	11 3	10 6
East Rand Proprietary	10 9	6 3
Ferreira Deep	1 3 9	16 0
Geduld	2 1 6	2 1 3
Geldenhuis Deep	1 3 9	15 6
Gov't Gold Mining Areas	2 15 6	3 15 6
Heriot	2 7 6	1 10 0
Jupiter	7 6	6 0
Kleinfontein	1 3 0	1 1 3
Knight Central	9 3	4 3
Knight's Deep	1 2 6	11 3
Langlaagte Estate	17 6	14 9
Main Reef West	4 0	2 9
Meyer & Charlton	5 11 3	5 11 3
Modderfontein (£4)	19 5 0	23 3 9
Modderfontein B	7 11 3	8 13 0
Modder Deep	7 0 0	7 10 0
Nourse	1 1 3	1 0 0
Rand Mines (5s.)	3 11 3	2 18 9
Rand Selection Corporation	3 10 6	4 10 0
Randfontein Central	12 0	12 0
Robinson (£5)	18 9	1 0 0
Robinson Deep A (1s.)	1 13 9	1 5 0
Rose Deep	1 0 6	1 2 6
Simmer & Jack	7 0	5 3
Simmer Deep	4 0	3 6
Springs	2 16 3	3 13 9
Sub-Nigel	1 3 9	1 10 0
Van Ryn	1 18 0	1 3 0
Van Ryn Deep	3 7 0	3 13 9
Village Deep	1 8 9	1 1 3
Village Main Reef	16 3	14 9
Witwatersrand (Knight's)	2 13 9	1 16 3
Witwatersrand Deep	1 0 0	9 6
Wolhuter	9 9	6 6
OTHER TRANSVAAL GOLD MINES:		
Glynn's Lydenburg	16 3	1 0 0
Sheba (5s.)	1 3	1 3
Transvaal Gold Mining Estates	1 1 3	18 3
DIAMONDS IN SOUTH AFRICA:		
De Beers Deferred (£2 10s.)	13 7 6	12 17 6
Jagersfontein	4 7 6	4 5 0
Premier Deferred (2s. 6d.)	7 10 0	7 7 6
RHODESIA:		
Cam & Motor	9 9	13 3
Chartered British South Africa	12 0	16 0
Eldorado	9 0	9 0
Falcon	15 0	1 7 9
Gaika	9 0	1 6 3
Giant	6 6	9 6
Globe & Phœnix (5s.)	1 12 0	1 11 3
Lonely Reef	1 8 6	1 17 0
Rezende	3 6	4 5 0
Shamva	1 1 3	1 15 0
Wanderer (3s.)	1 3	1 9
Willoughby's (10s.)	4 3	6 0
WEST AFRICA:		
Abbontiakoon (10s.)	5 0	4 3
Abosso	8 0	7 9
Ashanti (4s.)	18 6	1 0 6
Prestea Block A	6 0	4 9
Taquah	17 0	16 3
WEST AUSTRALIA:		
Associated Gold Mines	4 0	2 9
Associated Northern Blocks	3 0	2 9
Bullfinch	1 9	2 0
Golden Horse-Shoe (£5)	1 13 9	2 7 6
Great Boulder Proprietary (2s.)	11 3	13 6
Great Boulder Perseverance	1 0	—
Great Fingall (10s).	1 0	2 0
Ivanhoe (£5)	2 0 0	2 7 6
Kalgurli	8 6	9 3
Sons of Gwalia	13 9	12 0

GOLD, SILVER, *cont.*	Feb. 5, 1917 £ s. d.	Feb. 5, 1918 £ s. d.
OTHERS IN AUSTRALASIA:		
Mount Boppy, New South Wales	7 0	6 0
Talisman, New Zealand	7 6	15 0
Waihi, New Zealand	1 13 6	1 18 3
Waihi Grand Junction, New Z'lnd	15 9	17 9
AMERICA:		
Alaska Treadwell (£5), Alaska	2 10 0	—
Buena Tierra, Mexico	8 0	12 0
Camp Bird, Colorado	5 6	7 9
Casey Cobalt, Ontario	6 0	6 6
El Oro, Mexico	7 0	9 3
Esperanza, Mexico	8 0	9 0
Frontino & Bolivia, Colombia	12 9	12 9
Le Roi No. 2 (£5), British Columbia	10 0	6 3
Mexico Mines of El Oro, Mexico	4 7 6	5 12 6
Oroville Dredging, California	15 0	18 9
Plymouth Consolidated, California	1 1 3	1 2 0
St. John del Rey, Brazil	15 9	18 0
Santa Gertrudis, Mexico	8 3	13 9
Tomboy, Colorado	19 6	19 6
RUSSIA:		
Lena Goldfields	2 5 0	1 5 0
Orsk Priority	1 1 3	10 0
INDIA:		
Champion Reef (2s. 6d.)	6 0	5 9
Mysore (10s.)	3 3 9	3 5 0
Nundydroog (10s.)	1 5 0	1 6 0
Ooregum (10s.)	19 6	19 6

COPPER:

Arizona Copper (5s.), Arizona	2 2 6	2 7 6
Cape Copper (£2), Cape Province	4 4 0	2 15 0
Chillagoe (10s.), Queensland	3	1 3
Cordoba (5s.), Spain	4 0	3 6
Great Cobar (£5), N.S.W.	2 0	1 6
Hampden Cloncurry, Queensland	1 13 9	1 12 3
Kyshtim, Russia	2 12 0	1 3 0
Messina (5s.), Transvaal	10 0	8 0
Mount Elliott (£5), Queensland	5 5 0	4 0 0
Mount Lyell, Tasmania	1 5 0	1 7 0
Mount Morgan, Queensland	1 11 9	1 14 3
Rio Tinto (£5), Spain	61 15 0	64 5 0
Sissert, Russia	1 7 6	1 0 0
Spassky, Russia	1 17 6	1 2 6
Tanalyk, Russia	2 7 6	1 3 0
Tanganyika, Congo and Rhodesia	2 8 9	3 12 6

LEAD-ZINC:

BROKEN HILL:		
Amalgamated Zinc	1 10 6	1 11 3
British Broken Hill	1 8 0	1 17 3
Broken Hill Proprietary (8s.)	2 6 6	2 17 0
Broken Hill Block 10 (£10)	1 0 0	1 8 3
Broken Hill North	2 6 6	3 0 0
Broken Hill South	8 2 6	10 15 0
Sulphide Corporation (15s.)	1 5 0	1 7 0
Zinc Corporation (10s.)	14 6	1 1 0
ASIA:		
Burma Corporation	3 16 3	4 6 3
Irtysh Corporation	2 5 6	1 4 6
Russian Mining	1 1 6	10 0
Russo-Asiatic	5 10 6	2 17 6

TIN:

Aramayo Francke, Bolivia	1 10 0	1 16 3
Bisichi, Nigeria	11 0	15 0
Briseis, Tasmania	4 6	5 9
Dolcoath, Cornwall	9 9	12 9
*East Pool, Cornwall	1 10 0	1 4 6
Ex-Lands Nigeria (2s.), Nigeria	1 6	2 3
Geevor (10s.) Cornwall	10 3	18 0
Gopeng, Malay	1 10 0	1 16 3
Ipoh Dredging, Malay	13 [illegible]	15 6
Malayan Tin Dredging, Malay	1 17 6	2 3 9
Mongu (10s.), Nigeria	9 6	15 0
Naraguta, Nigeria	12 [illegible]	17 0
N. N. Bauchi Pref. (10s.), Nigeria	7 9	12 3
Pahang Consolidated (5s.), Malay.	9 6	11 0
Rayfield, Nigeria	7 3	11 9
Renong Dredging, Siam	2 5 0	2 7 6
Ropp (4s.), Nigeria	17 6	18 0
Siamese Tin, Siam	2 7 6	3 0 6
South Crofty (5s.), Cornwall	15 0	1 12 0
Tekka, Malay	3 0 0	3 15 0
Tekka-Taiping, Malay	3 0 0	3 15 0
Tronoh, Malay	1 7 0	1 12 0

* £1 shares split into 4 of 5s. each in August 1917.

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also reviews of new books, and abstracts of the yearly reports of mining companies.

FIGHTING THE MOSQUITO AT MESSINA MINE.

The *South African Mining Journal* for November 17 reprints an article by Dr. W. R. Greening that appeared in the *South African Medical Journal* describing the steps taken to combat malaria and exterminate the mosquito at the Messina copper mine in the Northern Transvaal. This mining camp consists of approximately 500 whites and 2,500 natives. Until these protective measures were taken, every year saw an outbreak of more or less severity, according to the rainfall, culminating in the season 1914 and 1915, when malaria was very rife, in some cases whole families being down at one time, and a large percentage of the mine staff constantly sick. The camp is surrounded by thick bush, interspersed by baobab trees, and bounded on the east by a range of huge kopjes, from the direction of which comes the prevailing wind; with these kopjes are large numbers of hollows, which hold water after rain. About 1½ miles to the south is a series of shallow water-holes, called Messina Waters, which contain water all the year round in greater or less degree, and which constitute a large breeding area for mosquitos. The majority of local cattle water here. Abutting on the township, and in the path of the prevailing wind, is a long, rocky flat, which contains a vast number of hollows in the rocks, which become pools during the wet season. From a sanitary point of view, the camp was far from perfect, and many conditions favoured the breeding of mosquitoes right in the heart of the camp. There was no provision for carrying off waste water, and the water from baths ran directly on the ground, some householders diverting this water on to gardens and hedges, many making a practice, in fact, of letting the tap run and guiding the water by means of pipes about the garden. The result was that ideal breeding-places were set up, as the water remained in hollows among the vegetation, kept cool and protected from evaporation by the leaves above. In many of the quarters the branches of trees had grown higher than the guttering of the roof, and it was found that the falling leaves, together with dust, clogged the guttering and dammed the water after each rainfall. Many householders had paw-paw trees growing in their gardens, many of which were found to have hollows in the trunks, into which water gained admittance through small holes. There was no provision for dealing with rubbish from the camp, and it was merely collected from the houses, carted a short distance into the bush, and dumped in small heaps in all directions. Water at times being a rather scarce commodity, the householders, in many cases, used to store water for days in small tanks, cisterns, drums, or any receptacle handy, such water, of course, never being protected against mosquitoes in any way. Near the quarters was a huge dam, an excavation made in taking out earth for the manufacture of bricks for the houses close by; it was made in the track of a spring that ran for the greater part of the year, so that it contained water right through the season. There were also a couple of wells fallen into disuse, but containing water, and not protected or covered in any way. On the mine itself there were many conditions favouring the breeding of the mosquito. Old tanks, buckets, disused castings, and various parts of worn-out machinery that could contain water were to be found in profusion, while on the site of the old mill were masonry and concrete foundations with hollows where water could settle and lie for months protected from the sun, and thus from evaporation. Another great evil was that of squatters, who had large numbers of thatched huts built in the bush. These people were not served by the mine sanitary service, and scattered tins, etc., in the bush around their dwellings, and stored water, carried from the mine, in tins and drums of all kinds, and in no case protected.

Early in 1915, when the fever was at its height, and the local hospital contained more patients than it was ever designed to hold, even then falling short of the demands made on it, the campaign against the mosquito was started. All houses were screened. A large gang of boys was started on bush clearing, and before long the bush in the camp and for a large area around had been cleared and the roots dug out. All tins and bottles, and anything that would hold water, were gathered up and buried. The squatters were gradually brought into the camp as quarters could be arranged, and the huts demolished. All dams or hollows were filled regardless of expense, and drains cut, where necessary, to carry off all storm water that might otherwise lie about, and the wells were sealed. In the quarters, the problem of waste water was overcome by putting in French drains and fitting grease traps; they were made of ample size and depth and without exception have proved satisfactory in practice. All creepers actually growing on houses were removed, as also the branches of trees over-hanging the guttering, and a clear space of 6 ft. was left between the house and any vegetation. The paw-paw trees with hollows were, in many cases, cut down, and in others the hollows were stuffed with clay. All disused tanks, old machinery, etc., on the mine that held any water were put in such a position that they could not hold water, or else broken up; old engine-beds were filled, likewise any hollows or crevices in the masonry that could hold any water. As regards the pools in the rocks, the idea at one time was to fill them with concrete, but as some of them are at a great height and in the most inaccessible places imaginable, it was decided to keep them well under control by the constant use of paraffin. Paraffining is also resorted to after each shower of rain, as water is caught in innumerable ways, in spite of all precautions; thus it is necessary to keep every nook and corner of the camp under constant observation. Householders leave water standing in the yards in various receptacles, contractors store it in tanks alongside their jobs, in the most careless fashion and in spite of all warnings, and one's vigilance must never be relaxed if any success is to be obtained. It has been found that some trees are a source of danger in that they harbour water for long periods after rain. One instance is the maroola tree. When the bush was cleared, several of these trees were left standing on the veld, for the reason that their branches are wide-spreading, and give good shade for children to play in; but as a result of a discovery recently made, all that were left are now being cut down. These trees have an innocent-looking little hole in the side of the trunk, at a height of about 5 or 6 ft. from the ground; it varies from 1 to 2 in. in diameter, and at a first glance one would not think that it penetrated to an extent worth considering. But it has been found that this hole leads to a cavity in the trunk capable of holding anything up to 5 or 6 gallons of water, according to the age and size of the tree, and moreover, owing to its sheltered position, the water remains in the trunk for a long time, sufficient for several successive lots of larvæ to hatch. Another tree that has needed special attention is the baobab tree. This tree has a huge trunk upwards of 20 ft. or more in height, and all the branches spread at the top of the trunk, thus forming a socket capable of holding water. These immense trees are very common, and none were removed when the bush was cleared; they have been rendered harmless by cutting one side of the socket in such a way as to render it incapable of holding water.

Another important work undertaken was the disposal of all rubbish in an effective manner, and in this connection a simple but permanent form of incinerator was devised, of which there are now two in constant operation. All refuse is brought to them, and boys sort out the tins and other incombustible matter, which they bury beneath the ashes of the remainder of the rubbish after it has been burnt. This is a simple matter, as the plant is built on sloping ground, and the ashes are run out with barrows and emptied after the manner of a mining dump, with the tins, etc., underneath. In August, 1915, a Public Health Committee was formed to deal with affairs in the township. This was necessary as there were 300 natives not in the employ of the company, and not under proper control from the health point of view; also a large number of poor whites were putting up huts in the bush, and living under insanitary conditions. A native location was formed in a suitable position, and the natives, who had been squatting where they chose, which was not always a very desirable position, were collected, and given stands in the location. The poor whites were likewise got together, and given sites on a cleared space, where their living conditions and sanitation would be under direct control.

Mosquitoes are bred in the mine, and in various ancient surface workings originally started by an unknown people. These are kept as much under control as possible, and it is likely that the level which is responsible for most of the mosquitoes will later on be closed up. It has been established that cattle, more especially those of a dark colour, have brought mosquitoes into the camp in their hair, and for this reason water-holes a considerable distance away have been brought under control. Any complaints as to the presence of mosquitoes in houses have been always attended to, and breeding places, previously overlooked, have been discovered and treated. Recently a complaint was received from the local police station. On inspection a maroola tree in the vicinity was found, containing a couple of gallons of water teeming with larvæ. After removal of the tree there were no further complaints. It is well-known fact that mosquitoes will travel miles on dark clothing, and they have been found on dark helmets worn by the police who have come into camp from patrol duty.

The campaign has been completely successful in its object, and during the last season, and the one now almost concluded, not a single case of fever has been incurred locally. It might be thought that the eradication of malaria during the last two years has been due to dry summer seasons, but this year, up to date, has averaged a higher rainfall than the average for the last ten years.

DRILLING IN THE ROUMANIAN OILFIELDS.

On January 15, Captain T. S. Masterson read a paper before the Institution of Petroleum Technologists on the Petroleum Industry of Roumania. We extract from this paper some of the author's remarks relating to drilling methods. Here we would remind readers that we published an article on the Roumanian oilfields by R. C. N. Twite in our issue of December, 1911.

In the early days, between 1886 and 1888, the first drilling was done on the Pennsylvanian system. With one notable exception, these borings were technical failures. In one district, the borings never got deeper than 1,000 ft., and at the other only one or two got beyond that depth. They either went out of plumb or became too small in diameter. It was found that the Pennsylvanian system would not work, as the beds would not stand up in the drilling unless the casing followed closely. Next to be used was the Canadian system, which was successful. At first slow progress was made on account of the constant need of using the under-reamer, but later, in 1898, with the more general introduction of the eccentric bit, the progress was better. The system has lived down to 1916, partly because of its steady, although slow, progress, and partly because of the preference shown for it by some operators who do not altogether trust the water-flush systems. A third factor responsible for the persistence of this system may be found in the enormous quantity of Canadian boring material and tools which had accumulated, and operators were reluctant to purchase new plant.

Various types of water-flush percussion systems were used after the year 1898, including the Vogt, Treschl, Travzl, and Marenholz, which are all on the same principle, but differ only in details of construction. For a number of reasons, not excluding local prejudice, these systems failed to make a permanent stay. They were chiefly used by contract drillers, and company managers generally did not favour them. It was only in later years when certain companies purchased their own plant, such as the Astra Romana, and Steaua Romana, that the water-flush percussion system came in for permanent use. In particular the Alliance rig used by the Steaua Romana was a notable success.

In 1904 the Pennsylvanian system was again introduced, this time by the Standard Oil Company, who sent out a large consignment of drilling plant, and a number of American drillers. It is curious to notice that, with the exception of its being of a heavier type, the same kind of plant was sent over as had proved a failure in 1886, and the same method of drilling was adopted. During the first few years only a few successful wells were drilled, and the majority, for technical reasons, were abandoned before the oil strata were reached. It was found that casing, including the heavier type of drive pipe, would not drive successfully through gravel or sands, and, indeed, at depths exceeding 1,000 ft. the casing would not drive at all. Calf wheels were introduced, under-reaming was resorted to, and eventually, three years later, after variable experience and much expense, which would have broken ordinary companies, the Pennsylvanian system became a success, but not until it had been adapted for manipulating and inserting casing *pari passu* with the advance of drilling. The water-flush percussion systems in the early days, when clear water was used for flushing, were subject to the same disadvantages, and casing had to follow the drill in the same way as with the dry systems.

In 1904 or 1905 the first rotary system was introduced, but, partly because the plant brought out was of too light a pattern, and partly because the rock in that particular region was not of the most suitable, these first efforts were failures. Later, in 1912, the rotary was again introduced, but, for reasons more of an administrative nature, there was again no success. The following year, however, the rotary was given a fair trial, and in suitable rock it proved a success, and the rotary will very likely be more widely employed in the future. The rotary in Roumania has been a great success, in the soft loose sandy marls of the Pontic beds at certain places. The use of thick mud-flush has made it possible to drill 1,600 ft. of uncased hole, and at one place wells have been drilled to 2,400 ft., at an average progress of 65 ft. per day, including the time needed for the setting of two strings of casing, and the exclusion of the water in the upper sands. This record compares very favourably with the achievements of the percussion flush systems. Daily drilling records of 250 and 300 ft. of 12 in. hole have been frequent. In sandy and small-gravel beds, the rotary has shown an advantage over the percussion systems, but in the beds of larger gravel and boulders the progress was less favourable, while in conglomerates and in sandstone progress has been very slow, the amount drilled in 24 hours often not exceeding 14 in., a progress not equal to that obtained with the percussion systems. This may have been due to the inferior kind of steel available for the bits, which could not be hardened sufficiently. They became blunt after ten minutes' use and any longer rotation had the effect of reducing the bit rather than cutting the rock. It was found that in hard gritty rock the best progress was made by pulling out and changing the bit at the closest intervals. It was also found, where big holes were drilled through hard sandstone, that ledges were left on the rock, which held up the casing when it was inserted, and reaming had to be resorted to, which operation very often required the same amount of time as the original drilling. Guides above the bit did not always exclude this trouble, although they were dangerous tools to have in the hole. The Sharp & Hughes bits were not sufficiently tested; for one reason because suitable sizes were not available, and no others could be introduced owing to war conditions.

The combination rig, that is, the rotary and ordinary percussion system, has not proved satisfactory where hard shells are met with at frequent intervals, inasmuch as one of the great advantages obtained by this rotary, namely, that of saving casing, was lost because, in the absence of thick mud-flush, casing would have to be inserted before the mud in the hole was thinned and made suitable for cable or solid-rod drilling. The author devised a method for overcoming this difficulty by the addition of a bullwheel to the rotary derrick, and the addition of a crank to a lengthened drilling shaft, with the object of using hollow flush-poles for spudding through the hard shells. The advantage of the arrangement consists in not over-burdening the derrick, as would be necessary in the case of the introduction of the walking-beam, and secondly, in so far as the continuation of flushing with the same mud as used for rotary drilling makes it unnecessary to insert casing. Another advantage afforded is that no loss of time is involved in the change from one system to the other.

It has been stated that the rotary, on account of its speed, and the heavy weight of the flush-mud, frequently allows oilsands to be drilled through and "mudded off" without being observed. Of course this is possible with the rotary as with any other system; perhaps more so with the flush systems, for in the case of thin oilsands, the sand which is flushed up is often mixed in such small proportions with samples of the preponderating rock that the sand can hardly be identified. In any case the sample is not so pure as that brought up in a bailer from the bottom of the hole in the case of percussion nonflush drilling. But vigilance is necessary with any system, and many an oilsand has been drilled through undetected even with the Canadian and Pennsylvanian systems. With a certain amount of vigilance no oilsand need be passed unobserved, even where there is no big gas pressure.

In addition to the wells which came under the author's personal observation, he has made inquiries as to the results obtained from most of the rotary bores in Roumania, and it may fairly be stated that all oilsands can be detected by vigilant and experienced drillers. The oil contained in the thickness of the sand penetrated usually comes up to the surface, and the fresh lively oils thus displaced can hardly be mistaken for the grease or dead oil that might have got into the flushings as a result of oiling of the machinery parts. Shows of oil from an upper source which it is intended to neglect are also mudded off if circulation is not lost. Where the oil is struck at low pressure or in partly exhausted sands, an immediate loss of the flush water is observed, which gives the needful indication to those in authority to decide as to whether a test is necessary or not.

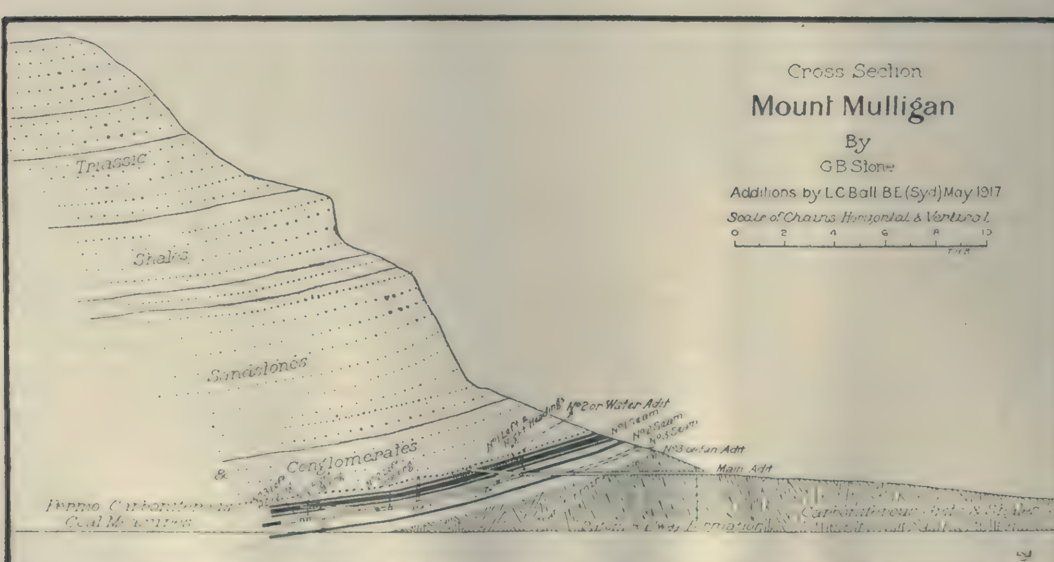
There is one more point in favour of the rotary, and that is that, on account of the mudding up of the walls, it facilitates the shutting off of water, particularly when the hydrostatic pressure is not great. Where the annular space behind the casing has to be washed for the purpose of using cement this advantage is lost.

As regards labour, American drillers came over in 1886, but left when the borings for which they had been brought out were stopped. With the advent of the Canadian system all the skilled labour was imported from Galicia. Polish drillers and aids came over in large numbers until the year 1904, when native Roumanians, who were being employed in increasing numbers, gradually replaced the Polish labour. By 1916 nearly all the Canadian rigs were run by natives, as were also those operated on the Pennsylvanian system. The first work was conducted with American drillers and tool dressers, but in the last two or three years natives were replacing the Americans, who were given the work of supervision. The rotary drill, although only of recent advent, was being manned largely by Roumanians. The Roumanian peasant, who is superseding the foreign driller, is an intelligent and conscientious worker, but lacks education, which makes it difficult for him to grasp mechanics. This is easily understood when it is remembered that Roumania is essentially an agricultural country.

The following table gives the output of petroleum in Roumania during the twelve years from 1904 to 1915:

Year	Tons	Year	Tons
1904	500,561	1910	1,352,407
1905	614,870	1911	1,544,847
1906	887,091	1912	1,804,761
1907	1,129,297	1913	1,885,225
1908	1,147,727	1914	1,783,947
1909	1,297,257	1915	1,673,145

MAP OF NORTH QUEENSLAND, SHOWING POSITION OF MOUNT MULLIGAN.
(Since the map was drawn, Mount Mulligan has been connected by railway with Dimbulah)



MOUNT MULLIGAN COALFIELD, NORTH QUEENSLAND.

The coal deposits at Mount Mulligan, North Queensland, have been known for a number of years, and they were worked first in 1911 by the owners, the Chillagoe Company. It was hoped by means of this coal and the coke produced from it to put the Chillagoe smelters on a more profitable basis than was possible with coke imported from New South Wales or elsewhere. The *Queensland Government Mining Journal* for September contains a paper by Lionel E. Ball, Government Geologist, on these deposits and the developments to date. As will be seen from the illustrations, the Coal Measures, which belong to the Permo-Carboniferous series, outcrop at the base of steeply rising ground. They lie upon fine-grained micaceous grits and shales of Carboniferous age. Over them are conglomerates, sandstones, and tuff-shales, which Mr. Ball identifies as belonging to the Trias. The Coal Measures are 111 ft. thick, but no individual seam of coal fit for coking is thicker than 2 ft. 3 in. The accompanying table gives details of the various seams, together with the bands of sandstone, shales, and fire-clays. Altogether 44 ft. out of the 111 ft. is coal. The coal can be segregated into three seams. The upper section of the top seam contains a bed of coal 2 ft. 1 in. thick. The lower section contains a bed 2 ft. 3 in. thick. No. 2 seam contains a coal bed 2 ft. 1 in. thick with a thin bed, 3 in. thick, just below. No. 3 seam contains a bed 3 ft. thick, but of very poor quality. The coal throughout the deposit is extremely variable in character. Some of the seams consist almost wholly of friable, bright, jet-like coal without any trace of lamination, and comparatively low in ash. Others are a tough and dull "splint," conchoidal in fracture. Others again are composed of interlaminated bright and dull coal with shaly bands. When delivered for use on locomotives the coals from various seams are mixed, the first class predominating, the mixture averaging 17% ash. The coal classed as bright and jet-like averages 8% ash; the "splint" 20% ash, and the interlaminated bright and dull 10% ash. As regards the relative content of fixed carbon and volatile matter, a characteristic analysis of the "splint" is: 25% volatile, 54% fixed carbon, 20% ash; while the bright coal will contain 35% volatile, 55% fixed carbon, and 8% or more ash. In tests on the railway, the best picked bright coal gave results nearly as good as the coal from Newcastle, New South Wales. As regards suitability for coking, the experiments show that some of the coal is suitable for this purpose, though the coke will be generally high in ash. It will be necessary to introduce some method of picking or coal-washing in order to remove the earthy minerals so as to improve the quality of the coal used for coke-making, and also of that used for steam-raising, for in the latter case clinkering causes trouble in the grates. The mining of the coal will have to be done by mechanical coal cutters and face belt-conveyors, owing to the narrowness of the beds. At the present time labour is scarce, and the coal mines do not provide an attraction to the workers. At the time of Mr. Ball's visit in September, the shipments of coal were only 40 tons per week, just half of what they were nearly two years ago. With an output of 250 tons per week, the present possible maximum, it is hardly possible that operations can be profitable. The average individual hewer's production is about 3 tons per day, but with additional mechanical cutters a greater output could be obtained. At present only one cutter is at work. We refer in the Review of Mining in this issue to the rearrangement of the Chillagoe Company's operations.

SECTION OF MOUNT MULLIGAN COAL MEASURES.

	Ft.	in.	
Shale, sandy in places, uppermost 12 in. very coaly	2	0	
Clay band	0	1	
Shale, dark grey	4	6	
Clay band	0	1	
Sandstone	0	4	
Coal, bright and dull laminated, probably high in ash	0	10	
Clay band	0	0½	
Coal, bright and dull laminated, probably high in ash	1	5½	
Coal, with clay bands	0	4	
Clay bands	0	2	
Coal	0	11	
Clay	0	1	
Coal	0	9½	
Clay	0	2	
Coal	0	2	
Clay	0	5½	
Coal	0	3	
Clay	0	1½	
Coal	2	1½	
Shale, dark and sandy in parts	0	9½	
Sandstone	4	0½	
Coal	0	7	
Shale, dark and sandy in parts	1	7	No. 1 Seam.
Coal, dull splint on whole	1	1½	
Shale, dark and sandy in parts	1	3	
Coal	0	6	
Sandstone	0	6½	
Coal	0	5	
Shale	0	9	
Coal	1	11	
Shale	0	7½	
Coal	0	3	
Shale	0	4½	
Coal	2	3	
Shale	1	7	
Sandstone, shaly towards base	2	9	
Coal, mostly bright, some splinty and slightly crushed	1	0	
Shale, with 2 in coal 8 in. above base	1	11	
Coal (thinning to ½ in. in places)	0	1½	
Shale (fireclay)	0	6	
Coal, very dirty, splinty and slightly crushed	1	0	
Shale	4	6	
Sandstone, rather fine grained and micaceous	3	5	
Shale	1	7	
Coal, upper 2 in. very splinty, lower 3 in. bright	0	5	
Shale, with polished heads	3	11	
Coal, laminated bright and dull	0	10	
Shale	1	6	
Coal	0	4½	
Shale, in some parts very coaly	0	8	
Coal, bright	0	2	
Shale (fireclay)	1	8	No. 2 Seam.
Coal, mostly bright	2	1	
Fireclay, with efflorescent sulphate in old workings	0	6	
Coal, generally crushed, often very shaly, and known as "pricking"	0	3	
Shale, soft laminated fireclay	0	3	
Sandstone, with ironstone bands	4	4	
Shale, massive slightly gritty	3	5	
Sandstone, massive	17	7	
Shale	6	4	
Coal	1	2	
Clay	0	3	
Coal	0	3	
Shale	0	2	
Clay	0	3	
Shale, sandy	0	10	
Coal	1	7	
Sandstone	0	3	No. 3 Seam.
Shale } Splinty coal and shale	0	1½	
Coal } Splinty coal and shale	0	1½	
Coal	3	3	
Shale (fireclay)	0	9½	
Coal	1	11	
Shale (fireclay)	0	3½	
Coal	0	4	
	111	2	

OIL SHALES IN SOUTH AFRICA.

Last month we quoted from a paper by Dr. Percy A. Wagner appearing in the *South African Journal of Industries* dealing with the prospects for petroleum and oil-shales in South Africa, giving that part of the paper relating to petroleum and bitumens. Herewith we give extracts from the section in which he discusses the oil-shale resources.

Contrary to common belief, normal oil-shales contain no free petroleum but a series of substances of organic origin, grouped somewhat vaguely under the name kerogen, which on being heated in a suitable retort give off hydrocarbons of the aliphatic series, olefines, paraffins, etc. In the oil-shales of Scotland, France, and New South Wales, and also those of some of the occurrences in the Ermelo and Wakkerstroom districts of the Transvaal, the oil-yielding substance has been shown by microscopic examination to be in the form of minute globular or irregularly shaped, translucent, yellow bodies. These have been the subject of a great deal of controversy since the year 1853, when they were first described by Professor Queckett in a paper read before the Microscopical Society. That scientists are still far from being unanimous in regard to their nature will be apparent from the fact that of recent years they have been variously interpreted as the thalli of gelatinous algae, the spores of vascular cryptogams, globules of inspissated petroleum, and resin fragments. Whichever of these interpretations may be correct, it is clear that oil-shales, which in their mode of occurrence are essentially similar to coal, must have originated in much the same manner as that substance in swamps, lakes, or lagoons, or, as is assumed to be the case with the Scottish shales, as quite estuarine mud flats to which an abundant supply of finely macerated vegetable matter was contributed by water flowing from swamp areas. Oil-shales differ considerably in appearance and properties. Those in Scotland are tough, sectile, leather-like rocks of deep brown or black colour capable of being cut with a knife into curly shavings. The shale of Kikvorschfontein, in the Wakkerstroom District of the Transvaal, approximates in character to typical Scottish oil-shale, but generally speaking the South African oil-shales are finely laminated, brittle, black rocks, which scrape to a gritty dust when tried with a knife.

In South Africa oil-shales have been found in the Karroo formation, as developed in the eastern part of the Union, over a very wide area extending from Middelburg in the Transvaal to Nahainkwe in the Matatiele District of East Griqualand. They occur in at least two divisions of the Karroo System, namely, the Stormberg series and the Coal Measure series of the Transvaal and Northen Natal, and at least two horizons in the last-named group of rocks. The existence of the shales has now been known for over twenty-five years, and while no great measure of success has so far attended the efforts of the various companies and syndicates that have been formed to work, or more correctly speaking, to explore the deposits, the prospects of establishing a shale-oil industry appear very hopeful.

Four areas have up to the present attracted particular notice. They are: (1) the central portion of the Ermelo district of the Transvaal; (2) the Wakkerstroom district of the Transvaal; (3) the north-eastern portion of the Utrecht district of Natal; (4) the eastern part of Impendhle county, Natal. In the three first-named areas the oil-shales occur in the Coal Measure series; in the last named in the Stormberg series. The oil-shales of the Ermelo district have for a number of years engaged the attention of mining engineers and prospectors, and a good deal of exploratory work has been done at different times with, on the whole, rather disappointing results. The Coal Measures, consisting chiefly of sandstones with intercalated shales and one or more seams of coal, are comparatively thin in this district, the maximum thickness disclosed by bore-holes being 613 ft. 6 in. They overlie an inconsiderable thickness of Dwyka tillite which, in turn, reposes on granite. The strata are horizontally disposed. A series of bore-holes put down some years ago on the farm Mooifontein No. 287, situated about eight miles north of Ermelo, proved the existence of three, and in some instances of four, distinct beds of carbonaceous shale. The lowest of these, with a thickness of from 20 ft. to 24 ft., directly overlies the Dwyka. The shale, a some what gritty black rock, on being subjected to destructive distillation yields light oil, but in quantities far too small to warrant its description as oil-shale. The so-called "middle" shale, which occurs in one large seam up to 19 ft. in thickness, or as two smaller seams respectively about 4 ft. and 5 ft. thick is intercalated with sandstones and shales from 85 ft. to 100 ft. above the bottom seam. From specimens of this shale obtained from a bore-hole on the eastern portion of Mooifontein, small quantities of oil were obtained on distillation, but on the western portion of the farm it proved to be absolutely barren. The "top" shale, which lies about 150 ft. above the "middle" shales and crops out at the surface on the western portion of the farm, is the only one of the three beds that appears to hold out any promise. It underlies, and is actually in contact with, a thin but persistent seam of coal to which further reference will be made. It is a well-bedded, black, micaceous shale which burns freely when ignited, leaving a white ash. The thickness, unfortunately, is small, ranging from a few inches to 2 ft. 8 in. A prospecting shaft put down some years ago on Mooifontein to intersect the seam showed: coal 1 ft. 10 in., oil-shale 1 ft. 6 in. A bore-hole on the same farm: coal 2 ft. 3 in., oil-shale 2 ft. A more recent bore-hole: coal 2 ft., oil-shale 1 ft. 8 in. Distillation laboratory tests made in Johannesburg and London on samples of the shale from Mooifontein showed from 30 to 32·5 gallons of crude oil per ton, and as much as 64 lb. 13 oz. of ammonium sulphate. The crude oil contains 1·7% of sulphur, and on fractionation yields: petroleum spirit 5%, illuminating oil 36%, lubricating oil 38%, pitch (still bottoms) 21%, total 100%. A test of the crude oil for paraffin wax gave 6 lb. 13 oz. per ton of shale.

These yields of crude oil and ammonium sulphate compare favourably with those of Scottish oil-shale, and, if worked together with the overlying coal, the inconsiderable thickness of the shale bed would be no serious deterrent of its profitable exploitation. Unfortunately, however, the shale, while it has been shown to exist at a number of widely separated points in the Ermelo district, does not form a continuous layer, but occurs in irregular patches, and as yet none of these has been proved to be of sufficient extent to be worthy of exploitation.

On the farm Waaihoek, situated 20 miles east-south-east of Ermelo and about 25 miles from Mooifontein, there is an exposure in the bed of a small stream of a seam of impure cannel coal which on distillation is said to have yielded 45 gallons of oil per ton and a very large quantity of inflammable gas. The seam is stated to be 2 ft. 9 in. in thickness, but only 1 ft. is exposed above the level of the stream. The same seam apparently occurs at Bank Plaats, 10 miles to the north-east of Waaihoek.

In the Wakkerstroom District on the farm Kikvorschfontein No. 4, situated about 20 miles north-east of Wakkerstroom, there is a very interesting occurrence of tough, horny oil-shale approximating in appearance and character to typical Scottish oil-shale. It forms a thin but persistent layer underlyiug a thin seam of cannel coal. The thickness of the shale is very small, rarely exceeding 3 in. and being frequently much less. It is a black, glossy rock with an irregular curly surface and a horny fracture. The streak is almost black. The shale is easily cut with a knife, and some of the specimens tested by the writer give a curved shaving. It can be ignited with a match and burns freely, leaving a little white ash. A number of tests have been made of this shale, and one has shown as much as 90 gallons of crude oil per ton. The average yield, however, appears to have been at the rate of from 40 to 60 gallons of oil and from 13 lb. to 20 lb. of ammonium sulphate. The crude oil obtained on fractionation yielded: petroleum spirit 6·3%, illuminating oil 26%, lubricating and heavy oils 64%, coke and loss 3·5%, total 99·8%. A good deal of work was done on the seam in 1903 by the Transvaal Oil Shale Syndicate, Limited, and also by an engineer sent out by the Rothschilds, but, owing to its very small thickness and the rather remote situation of the farms, prospecting operations were after a time abandoned. The cannel coal immediately overlying the oil-shale was found to yield 20·9 gallons of oil and 25 lb. of ammonium sulphate per ton. It has also a very high calorific value, but, unfortunately, the seam is too thin to be of economic value.

Another and apparently rather more promising oil-shale field is situated about ten miles to the south of Kikvorschfontein. It includes the farms Kromhoek No. 76, Virginia No. 371, Goedgeloef No. 279, and Morgenzon No. 163. The oil-shale, a friable, sandy carbonaceous shale, lies between 70 ft. and 80 ft. above a seam of bright bituminous coal. It appears to occur at practically the same horizon as the main oil-shale seam of the Utrecht district of Natal, and at a considerable distance above that of the Kikvorschfontein shale. The shale is said to be from 18 in. to 5 ft. in thickness and to yield as much as 60 gallons of crude oil per ton.

As regards the Utrecht district of Natal, the oil-shale deposits on the farms Winterplaats No. 48 W, Spruitfontein No. 238, Zuurboom, Roodekraal No. 65, Geluk No. 16, and Pongolo Bush, in the extreme north-eastern portion of the district, and on Zuurbronn No. 30, just across the Transvaal border, have attracted a good deal of notice, and this area is by many regarded as the most important oil-shale field in the Union. The two farms named first were during 1915 and 1916 the scene of fairly extensive prospecting operations by the Union Oil Company of South Africa, first under the direction of A. E. Blair and more recently under that of J. E. Mills Davies. They are situated immediately adjacent to the Transvaal border, at a distance of about 17 miles in a direct line from Wakkerstroom. According to a report by Mr. Mills Davies, the farms are occupied entirely by sandstones and shales belonging to the Coal Measure series and dolerite intrusive in these, a sill of the last-named rock, with a thickness of considerably over 100 ft., forming the top of the exposed section. The strata over the greater part of the farms dip at a low angle, about 5°, toward the north-east. Near the eastern boundary of the farms two small streams, which run in a northerly and southerly direction, respectively, and unite near the central boundary line, mark the axis of a shallow syncline. Toward the west, also, a slight change in the dip of the beds suggests the presence of a low anticline. The so-called "main" shale, of which the oil-shale bed forms part, is situated from 120 to 150 ft. below the thick dolerite sill, and about 70 ft. above the "upper" coal, a seam of bright bituminous coal ranging in thickness from 18 in. to 3 ft. Some 200 ft. verticaly below this seam is the "lower" coal, which, as exposed in the bed of the principal stream draining the area, is made up in descending order of 3 in. of coal, 12 in. of carbonaceous shale, and 3 ft. of coal, making a total thickness of 4 ft. 3 in. between a roof and floor of sandstone. An inferior coal-horizon, containing three narrow seams over a width of 10 ft., is exposed some little distance below this horizon, and still lower in the section are two thick seams of carbonaceous shale. The "main" shale has a thickness of from 20 to 22 ft., and lies between a roof of thickly-bedded sandstone and a floor of the same rock. Immediately below the sandstone roof there is from 1 ft. to 3 ft. of slightly gritty, dark carbonaceous shale that has been designated the "top" shale. Underlying this directly, or separated from it by a seam of soft rich shale from 1 to 2 in. in thickness, is the "middle" shale, which constitutes the portion of the "main" shale that has been proved to be economically valuable. It is a tough brownish-black dull lustreless rock with sub-conchoidal fracture. The thickness of the seam ranges from nothing to between 4 and 5 ft. Of these sub-divisions only the "top" shale appears to be continuous over the whole of the area occupied by the "main" shale. The other beds are of a lenticular character, sc that detailed sections of the main shale at different points exhibit considerable differences.

The oil shales of Impendhle county, Natal, occur at a very much higher geological horizon than those hitherto dealt with, namely, that of the Molteno Beds of the Stormberg Series. The shale outcrops are situated in the valleys of the Umkomaas, Hlatimbe, and Loteni rivers, in a tract of rugged country below the Drakensberg. The oil-shale horizon, which immediately overlies the Indwe sandstone, consists of from 10 to 15 feet of fire-clay, mudstone, and dark carbonaceous shale with one or more layers of oil-shale. As we gave a précis of A. L. Du Toit's report on these shales in our issue of December, 1916, we omit this part of Dr. Wagner's paper.

Bituminous shales occur in Southern Rhodesia in the so-called Black Shale group in which the Wankie main coal lies. Whether or not they come within the definition of oil shale is not known, but they are worthy of examination.

In concluding his article, Dr. Wagner says that the beds of oil-shale hitherto discovered in South Africa are thin in comparison with those being worked in Scotland and France, and not very rich. To some extent, however, this is compensated by the high price of mineral oils and oil products in South Africa. Such exploratory work as has been done on the deposits has clearly demonstrated that the oil-shale occurs in patches of varying thickness and quality, and that only systematic boring or prospecting by means of shallow shafts or adits can be relied upon to provide satisfactory data for calculations of quantity and average grade. Up to the present time only one small area, situated in the north-eastern portion of the Utrecht district of Natal, appears to have been properly examined, and if the figures published as a result of this investigation can be accepted, the area contains a sufficient tonnage of workable shale to warrant the erection of a plant capable of treating 300 tons per day.

MOLYBDENITE IN NORWAY.

At the January meeting of the Institution of Mining and Metallurgy, Mr. Ernest R. Woakes presented a paper describing the mining of molybdenite in south Norway, and giving information collected during a recent visit. This paper supplements one written by Mr. H. H. Claudet, a précis of which appeared in our issue of August, 1916.

Although molybdenite occurs in many parts of Norway, practically the whole of the production is obtained from mines in the southern portion, where the great mass of the country rock is granite or granite-gneiss. Most of the ore-bodies occur in this rock, but there are exceptions, notably the Gursli and Dalen mines. There are three fairly well-defined types of deposits. These are not always clearly distinguishable, even in the same mine, and the impregnated granite type occurs in more or less degree in all the deposits in that rock.

The first and possibly most important type is the quartz lode with its prominent outcrop. The Kvina and Knaben No. 1 mines are good examples of this type, though actually the mineral occurrences are very different in the two mines. The prosperous Dalen mine is another instance of a quartz lode, but here again the conditions are quite different from any other and the country rock is a silicious slate.

The second type is the most common, the most deceptive, and, in Mr. Woakes' opinion, the least likely to lead to any persistent or workable ore-bodies. In the Knaben district the type is common, and its characteristic is a highly mineralized fissure in the granite, running more or less parallel to the strike of the quartz veins of the district, N.N.E. and S.S.W., and dipping rather flatly to the east. These fissures sometimes have a certain amount of width which is filled in with more or less decomposed granite. Little free quartz is seen, but at and near the surface the faces of the fissure and the filling matter are often highly mineralized with molybdenite. At a few feet below the surface nothing is left but an ill-defined fissure or fracture, but the country rock is sometimes slightly mineralized for short distances along and on both sides of the fissure. There are many examples of this class of mine in Norway.

The third type is the molybdenite-impregnated granite. There are two or three promising looking occurrences of this type in Norway, of which Knaben No. 2 mine and the Undal mine are examples, while Gursli apparently has a molybdenite-impregnated norite deposit. None of these has yet reached the producing stage, but all should shortly arrive at that condition, and this type may yet prove to make the most successful mines.

Practically all the successful molybdenite concentrators in Norway are Elmore vacuum concentrators. A Swedish firm now controls the patent rights in Scandinavia and manufactures the plant. All the mills are similar in design. The ore from the mines is first crushed in Blake type rock-breakers, then passed through a ball-mill, the favourite type of ball-mill at present being the Gröndal made by the firm of that name in Stockholm. After the requisite sizing and return of the oversize to the Gröndal, the ore passes on to the Elmore units. Mica and copper are the impurities which cause most trouble; where these do not occur in undue proportion a good extraction is obtained and the concentrate runs from 75% to 80% MoS_2.

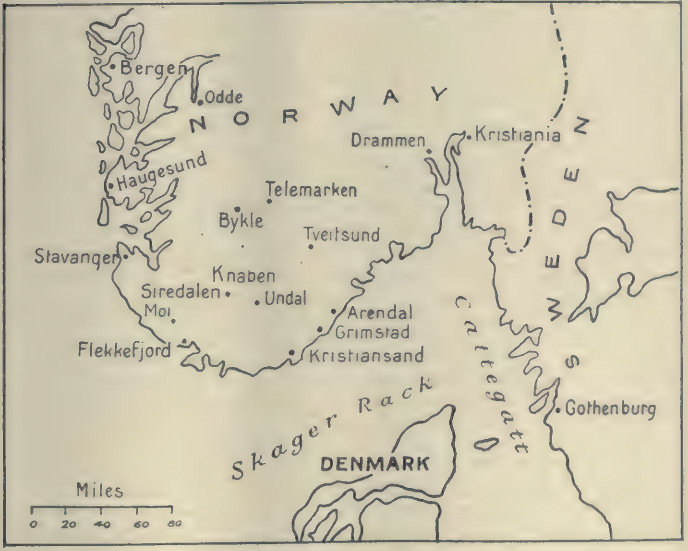
The accompanying table gives the names of the molybdenum mines and prospects at present operating in Norway. They are grouped according to districts.

Name of Mine	Name of Company or Owner	Class
Knaben District:		
Knaben No. 1	Blackwells Development Corporation, Ltd.	A
Knaben No. 2		C
Kvina	A/S Kvina Gruber	A
Ornehommen	A/S Ornehommen Gruber	A
Baenkebei	Ths. S. Falck	A
Lilleknaben	Anglo-Scandinavian Minerals, Ltd.	C
Hommen	Nielsen, Stavanger	C
Roma	A/S Roma Gruber	D
Sandtjern	A/S Molybden	D
Lister & Mandal	Herr Hjelm	D
Moi District:		
Gursli	A/S Gursli Gruber	A
Gursli II.	T. H. Falck & Blumental	D
Siredalen District:		
Orsdal	Kristiania Minekompani	C
Sandsmark	A/S Sandsmark Gruber	C
Mandal District:		
Undal	A/S Undalen Gruber	A
Bykle	Kobernuteus Interesenskab	D
Telemarken District:		
Dalen	A/S Dalen Gruber	A
Haugholmen	Herr Tarjer Midbgarden	B
Bandaksli	Kristiania Minekompani	B
Noraberg	,, ,,	D
Berge Gruber	,, ,,	D
Sinnaes	,, ,,	D
Dramen District:		
Syversvolden	Syversvolden Gruber, Sell & Gurholdt, Kristiania	B
Haugesund District:		
Skjold	A/S Skjoldevig Molybden	D
Northern Islands and Districts		
Vatterfjord	A/S Vatterfjord Molybden Gruber	A
Langvaten	?	D
Tjaarsdalskampen	?	D
Smolen	?	D

A represents a producing mine with a concentrator; B, a producing mine without a concentrator; C, a mine that will probably be a producer, and is erecting a concentrator; D are chiefly prospects, or mines which are closed down or which only produce negligible quantities of mineral.

The Knaben district is best reached by rail from the port of Stavanger to Flekkefjord, thence by motor boat to Oie, and by cart road to Knaben. The Knaben No. 1 mine is the oldest in the district, and has been a continuous producer on a considerable scale. The mine is owned by a British company, which is now opening and equipping a new No. 2 Knaben mine. The bearing of all the lodes in the district is approximately N.N.E. and S.S.W. with a flat underlie to the east. The mine consists of an adit level and a 60 ft. and an 80 ft. level below the adit. At and above the adit level, in the main ore-body, three lodes or branch lodes are worked and the rock between them was often mineralized. Below the adit only the eastern or hanging-wall lode shows any strength, and very little ore has been found at or below the 80 ft. level. In the upper workings the mineralization occurred over a width of 30 ft., with some fine veins of solid minerals. Masses of solid molybdenite have been found, and one piece weighing over 4 cwt. was presented to the Sheffield University. The hanging-wall is gneissic granite, whilst the foot-wall is often porphyritic. Outside the main ore-body the fissure is badly defined and erratic, and there is little impregnation of the country rock with molybdenite. There remains a considerable tonnage of arches and pillars to remove, and several thousand tons of dumps and tailing to re-treat. The output has not been regular and has averaged 5 tons of 75 to 90% concentrate per month. This plant has produced some very high-grade concentrate, as high as 94%, but latterly the grade has been lower.

The Kvina mine is situated on the same mineral belt as the Knaben, and about a mile to the noith. The lode is flat and worked entirely through adits. At the surface there was a strong quartz outcrop, but the lode was never defined as at Knaben No. 1. The hanging wall is granite, and the foot-wall appears to be entirely broken up, and a large amount of segregation to have taken place, so that masses of quartz and pegmatite are found. The ore makes at the contacts of the quartz and granite, and also at the quartz and pegmatite contacts, and there is a good deal of impregnation of the granite. Masses of molybdenite-impregnated rock often occur in the foot-wall, apparently far removed from any contact. The ore is low grade, probably about 0·3% or even less. At pre-war prices there can have been but little profit; now, however, the company is doing well, and produces from 3 to 4 tons of 75% concentrate per month. Knaben No. 2 mine is situated about two miles south of Knaben No. 1. A mass of molybdenite-impregnated granitic gneiss is being developed. Cross-cuts and open cuts show this mass to extend over a length of several hundred feet, and in some places to over 100 ft. in width. Its depth is not known. Well-mineralized joints are found throughout the mass, which is expected to mill about 0·5% MoS_2. Crushing plant sufficient for two Elmore units is being erected, and one of the latter is already installed. The main adit cross-cut is being connected with the concentrator by means of an aerial ropeway about ½ mile long.



MAP OF SOUTHERN NORWAY SHOWING POSITION OF MOLYBDENITE MINES.

The Ornehommen is an important Norwegian company started since the war. The plant and workings are situated about a mile N.W. of Knaben No. 2. The company has erected an 80 hp. hydro-electric plant and a large concentrator capable of holding four Elmore units, two of which are erected; the mine and concentrator are connected by means of a short single-rope aerial tramroad. The mine consists of cross-cuts and adit levels driven on a narrow and erratic mineralized fissure in granite, and has produced a ton or two of concentrate since the starting of the concentrator in July last. Baenkehei is a small mine adjoining No. 2 Knaben on the N., where the work is also on a small mineralized joint in the granite. The plant consists of an oil engine and one flotation unit, which started in July. A ton or two of low-grade concentrate has been produced. Lilleknaben mine is owned by an English company, and is situated immediately south of No. 1 Knaben. The company is erecting a Minerals Separation flotation plant, but has not yet got to work. Little underground work has been done, but there was a fair showing on the surface in the form of a mineralized fissure. The Hommen mine is situated south of Knaben No. 2, and is being opened as a trial by some of the Kvina shareholders. A flotation unit is being erected. The Roma, Sandjern, Lister, and Mandal are all prospects, and so far have done little work.

In the Moi district, the Gursli mine is the only producer. It is situated within a few miles of Moi station on the railway from Stavanger to Flekkefjord. The company has been promoted during the war, and a large output from the mine is anticipated. The outcrop occurs on the face of a cliff on the shore of a lake, and two parallel fissures have been cross-cut and driven on at two or three levels. The rock in which the veins occur is probably norite, and the molybdenite is not as pure as that usually found in the Knaben district. Mica and copper pyrite occur in sufficient quantities to interfere with the concentration. At present the mine does not show indications that these mineralized fissures in the more basic rock will prove more prolific as molybdenite bearers than have the similar occurrences in granitic gneiss. Within a short distance of the mill the company has commenced work on a molybdenite-impregnated norite mass, but it appears to be of low grade and to carry the interfering minerals above mentioned. The concentrator contains a more ambitious crushing plant than is usual at these mines, and has two Elmore units erected, with space prepared for two more. Gursli II is at present only a prospect; it has been on the market for some time.

The Siredalen district is reached from Sirnes, a station on the railway near Flekkefjord. The Orsdal mine was from 1904 onward worked for some years by the British Molybdenum Co., Ltd., but after making a small production was abandoned, and has quite recently been taken up by a Norwegian company. The mine is interesting as producing small quantities of wolfram. The Sandsmark is quite a new local company and little is known of its prospects. A concentrator containing two Elmore units is being erected.

In the Mandal group, the Bykle is an old mine in a very inaccessible part of the country. The ore is low-grade and impure, and the mine is not at present in operation, though attempts have recently been made to restart it. The Undal is a new mine in a new district, and a wealthy Norwegian company has spent large sums on its development and equipment. No underground work has yet been done, but a number of open cuts over a length of 700 m. have shown the occurrence of three or more parallel joints or veins in granite. At some points these joints are well mineralized, and the intervening rock, over widths varying from 5 to 20 ft., is strongly mineralized with disseminated molybdenite. A well-built and rather ambitious-looking concentrator has been erected, containing powerful crushing plant with two Gröndal mills and four Elmore units. The motive power is a semi-Diesel engine. This company may have a successful future when it has overcome the preliminary treatment difficulties, and conditions in Norway become normal. [In the map the Bykle and Undal do not look as if they belonged to the same district; the explanation is that they are both in the Mandal valley.]

Telemarken district is best reached from the port of Arendal, thence by train to Tveitsund and by motor-car to Bandaksli, on Lake Bandaks. The Dalen mine is beautifully situated at the western end of Lake Bandaks. From Dalen a day's motor ride through magnificent scenery takes one to Odda on the Hardanger Fjord, where the Alby United Carbide works are situated. The Dalen mine started producing at the end of 1916, and since that date has produced more molybdenite than any other mine in Norway in a similar period. The mine is situated about 1,200 ft. above the lake, and is connected to the concentrator on the lake by an aerial ropeway. The Dålen ore deposit consists of a flat hungry looking quartz vein in a fine-grained silicious slate. The quartz vein varies in width from 3 ft. to a few inches, and outcrops on the mountain side over a length of 200 m. It dips slightly to the west and does not extend into the mountain, but peters out to a mere stringer in a length of 200 ft. The slate walls are perfectly clean, and there is absolutely no impregnation of molybdenite into the slate. The quartz vein is faulted by vertical faulting planes and in places one or two smaller and parallel veins are showing. In the neighbourhood are other masses of barren quartz, and a small copper mine has also been in operation. The quartz vein would appear to be an apophysis from the granite which occurs about a mile off on the south side of the lake, and the whole occurrence seems to indicate that the molybdenite in the granite is to be attributed to the quartz constituent of that rock. The concentrator contains two Elmore units, and oil engines are used for power. Beside the concentrate the mine produces clean hand-picked ore including crystals of molybdenite. A special price is paid for these crystals provided they attain a certain diameter. It is stated that the perfect cleavage of the crystals enables leaves to be separated of a mica-like form and that these leaves are used for the intensifiers in wireless telegraphy. The Haugholmen and Bandaksli mines are situated in the granite on the south side of the lake and produce a small amount of high-grade hand-picked ore. Berge Gruber, Sinnaes, and Noraberg are all prospects under trial, the two former near Vraadal, and the latter near Dalen.

In the Drammen district several trials have been made on small highly mineralized fissures in granite. Some fine specimens and a few hundredweight of clean hand-picked ore are obtained, but so far there are no mines of importance. The Syversvolden mine is being developed in a small way.

Near Haugesund a good deal of money is being spent at the Skjold mine in opening up a small outcrop of molybdenite, but little information is available.

As regards the northern districts, on the island of Ostvaago is a small mine called the Vattenfjord, equipped with one Elmore unit, which makes a very small and intermittent production. Molybdenite is said to occur among other places at Smolen, Langvaten, and Tjaarsdalskamped; but, as far as information goes, the production from the northern districts is at present insignificant.

In summing up the prospects for the future, Mr. Woakes says the owners of the mines hope, possibly with reason, that one result of the war industry will be that the new and extended uses found for molybdenum will involve a much greater demand after the war. They anticipate that this extra demand will have the effect of maintaining fair prices. Provided the post-war price does not fall below 80s. per unit of MoS_2, he believes the Norwegian output of molybdenum could be maintained at about 100 tons per annum, which figure would represent a doubling of the pre-war production.

Molybdenite in Manitoba.—The *Canadian Mining Journal* for December 1 contains an article by J. S. De Lury describing a deposit of molybdenite, recently discovered, on Falcon Lake, near the Lake of the Woods, at the south-east corner of Manitoba, near the borders of Ontario and Minnesota. The district is within easy reach of Ingolf, a station on the Canadian Pacific Railway, and of the Greater Winnipeg Water District Railway. The country is forested, but good rock exposures are found on many comparatively bare ridges. Pre-Cambrian rocks occupy the whole area for miles around. Long and relatively narrow belts of Keewatin rocks occupy troughs in a complex of granites. The Keewatin belt consists mainly of old basaltic lavas, some of them showing pillow structure and others grading into agglomerates, with here and there small bands of a light-coloured rock, which in some places suggested quartzites and in others felsites. These old basalts have been changed by folding and shearing, and by intrusions of granite, so that now they appear as schistose metamorphic rocks; the most prominent type being a chlorite hornblende schist. At least two, but possibly more, granite masses have intruded this area. An early grey granite is prominent in the district; it is seen to be the older, as it has in many places a pronounced banding, and besides it has been intruded by a second granite, a red variety which shows little or no banding. Connected with this later red granite, or possibly with a still later intrusion, are some pegmatites and aplites which appear in the granite complex and in the schist for some distance from the contact with the granite. The intrusion of these acid phases of the granite is the important geological event in connection with the formation of the molybdenite deposits. The pegmatite dykes, which are of interest in connection with the molybdenite, lie in the schists parallel to the granite contact, as a rule, but in places they cut the schists at small angles, and minor pegmatitic masses cut the cleavage planes of the rock at almost right angles. The dykes in the vicinity of the molybdenite prospects are confined to a band of the Keewatin about half a mile wide running parallel with the contact and adjacent to it. Typically the dykes are from 2 to 10 ft. wide, and occur in groups or pairs. They have a lens-shaped form and may be split more or less by bands of schist. Individually the dykes do not appear to be very persistent in width; but on the other hand there is a persistent zone of dykes, many of which are almost joined. Some individuals might be traced several hundred feet. The pegmatites vary in texture from coarse-grained varieties with large crystals and masses of mineral up to several inches in diameter to fine-grained types which grade in places into graphic granite and aplite. The prominent minerals of the dykes are quartz and felspars with minor and varying amounts of muscovite mica. In the pegmatitic mass, apparently as an original constituent of the rock, is molybdenite occurring in a variety of forms. Irregular prismatic crystals up to 2 or 3 in. in diameter and coarse radiating groups of lamellae of even larger size are found distributed here and there through coarse and fine-grained pegmatite. Fine-grained massive specimens were found in one place in a massive quartz phase of the pegmatite. Small grains and lamellae are present in parts of the aplite. On one of the claims in the main group a small dyke cuts across a vein of reddish quartz which is from 2 to 3 ft. wide and lies parallel with the schist. In this quartz vein, within a few feet of the dyke, are cross-fractures which carry lamellae of molybdenite. This is the only occurrence noted in the district where the molybdenite is secondary in the rock. Another occurrence of special interest was seen on a claim in a detached area. Here a quartz vein, from 2 to 3 ft. wide, carries along the walls numerous felspar crystals and small masses with an occasional lamellar mass of molybdenite. The molybdenite content of this vein is small, but the occurrence of bismuth in small grains in the quartz is of some interest, especially as it was not noticed in any of the true pegmatites.

The molybdenite, owing to its softness and toughness, is not likely to make a good showing on the weathered surface for the reasons that ice-action would tend to pluck it out and to wear it away from the surface. Any that might be spared this erosion would be weathered out later or at least disguised by alteration products. In support of this view is the fact that openings made in the dykes have invariably made better showings than would have been deemed possible from the aspect of the unbroken surface. Though molybdenite masses, usually small ones, were seen on the surface in several places, evidences of quantity could only come from those parts of the dykes that had been opened by blasting. In practically all of these pits, crystals and masses of molybdenite, usually 1, 2, or 3 in. in diameter, were exposed. At one point where a shot had exposed about a square yard of pegmatite three crystals of molybdenite were exposed, which together would weigh from ½ lb. to 1 lb. In the blasting of 7 or 8 cubic yards of the dyke-rock, 20 to 25 lb. of loose crystals and masses were gathered, while in the large unbroken blocks of rock piled on the dump, many more could be seen. The prominent type of occurrence of the molybdenite is in large crystals and lamellar masses which could be readily handpicked into an almost pure product. There is another type which if found in sufficient quantity would be of economic importance, the fine-grained variety as found in aplite. The nature of the ore makes sampling out of the question in the present state of development of the properties. It would be necessary to crush large masses of ore in order to get a fair sample, and insufficient material has been thrown out to give this quantity. It was judged from results of a hasty examination that the molybdenite content of the pegmatites would lie between 0·1 or 0·2% in some cases, to possibly 1% in others. It is possible that higher grade deposits will be brought to light with further work in the district. The showings warrant further prospecting in the vicinity of the granite contacts.

Cost of Precipitation of Gold by Zinc. — The *Monthly Journal* of the Chamber of Mines of West Australia for July, 1917, just received in this country, contains an article by W. B. Chomley, describing the method of precipitating gold from cyanide solutions at the Great Fingall mine, together with details of the cost. The high price and scarcity of zinc made it desirable to investigate alternative methods of precipitation or the use of other forms of zinc than shavings. It was found, however, that no results quoted by other metallurgists reduced the cost to the figures at Great Fingall, even at the high price of zinc ruling, so no alteration was made. Under these circumstances the author considers it will be helpful to other metallurgists to give particulars of the method and conditions at this mine. The average amount of sand and slime treated per month is 4,220 tons. Of this, two parts is sand and one part slime. The solutions from the two sections of the plant are mixed on their way to the precipitation boxes. About 300 tons of solution is passed through the boxes per 24 hours, having a cyanide strength of 0·04% and an alkalinity of 0·015%. The solution averages 5 to 7 shillings gold content as it enters the precipitation boxes, and the effluent averages from 0·2 to 0·5 shillings.

The precipitation boxes, of which four are kept in use, are built of wood, and are considerably larger than those installed on most mines in West Australia. Each has seven compartments with a capacity of 16 cu. ft., but only five compartments are in use. This makes a total of 320 cu. ft., or 1 cu. ft. approximately per ton of solution per 24 hours. Each compartment holds about 120 lb. of new teased zinc shavings, or slightly more of old zinc that has been in use some days. An even and equal flow of solution is maintained through the boxes by having a suitable reducer on the end of each delivery pipe. All the feed pipes draw from one trough, which has an overflow leading back to the mill circuit. A stream from the clarifiers, which in this case are disused leaching vats, keeps this trough nearly full, so that the boxes are fed under what is practically a constant head. Some such arrangement is necessary, as the capacity of the boxes is taxed so near to their limit that any temporary increase in the solution flow would result in high tails. The boxes are cleaned up twice a month, and the zinc is moved up once between clean-ups. At the mid-monthly clean-up the zinc is only washed and returned to the boxes after the sludge is removed. Frequent tests have demonstrated this intermediate clean-up to be necessary to maintain good precipitation. The addition of lead acetate has been tried at various times and in various ways, but results have failed to show that it exerted any beneficial effect. Experience has proved that, so long as the cyanide strength is maintained above 0·03% KCy, and no sudden drop in the alkalinity takes place, the box tail-values entirely depend upon the ratio of solution flow to zinc area. When overloading takes place, the falling-off in precipitation is not simply in proportion to the increased flow, but is very much greater. Cases have been observed where the tails of one box have risen to ten times the value of its neighbours, and the cause has been traced to an accident which increased its flow apparently not more than 50%, and on this being rectified they fell to normal without any addition or moving of the zinc. At the month-end clean-up only the very short zinc is dissolved, but all the rich zinc that is strong enough to be of further use is soaked in dilute sulphuric acid, and is subsequently scrubbed and returned to the boxes. For this purpose a spare precipitation box is used. The compartments of this are partly filled with a solution of about 5% H_2SO_4. The zinc, after having been roughly washed in its own solution, is placed in the acid and left to soak for several hours. When the adhering gold slime has been loosened sufficiently to permit of its being easily rubbed off, the acid is washed away by running a stream of water through the box, and the zinc can then be handled without inconvenience. Some gold always remains on the zinc, which usually assays about 0·04% or 5s. per lb. after being washed, while the gold removed by this process amounts to from five to ten times that value. The slime filter consists of a 20 in. ten-framed press. Formerly, this was filled by air pressure from a monteju, but this has been discarded in favour of a vacuum pump. The delivery ports of the press have been altered to connect with the suction of the pump, while the intake of the press connects with a pipe line having suitable connections opposite each acid tub and precipitation box. To these connections can be attached a length of hose fitted with a scrim-covered funnel, which can be dropped into one compartment to remove the sludge while washing is proceeding in another compartment. After the press has been used on cyanide slime, and before it is used for acid slime, it is an invariable rule to give it a water wash to remove traces of cyanide from the cloths. If this is not done, the acid, in coming in contact with the cyanide, will form various gelatinous compounds which retard filtration. This method of using a closed filter in conjunction with a vacuum pump has several advantages over both the ordinary pressure filter and the open-leaf vacuum filter. Unlike the former, it does not blow out when a leak occurs, and at the end of the clean-up there is no slime left behind in the monteju, which usually can only be recovered at the cost of some time and labour. The low pressure obtainable by a vacuum is compensated by the saving in time through being able to operate the filter continuously until full, instead of intermittently as is the case when using air pressure. It has an advantage over the open vacuum filter inasmuch as the cakes can be dried by air pressure and delivered in a convenient form. Over both it has the advantage of being able to collect the sludge and cloudy solution from the boxes and deliver the slime ready for roasting without any intermediate handling.

The slime is roasted on trays in a reverberatory furnace, fluxed with 40% of borax and 15% of sand. It is then smelted in No. 150 crucibles in two well furnaces. Formerly, a large tilting furnace was used, but as the total quantity of slime is under 300 lb. per month there is nothing to be gained by continuing its use. The coke consumption of these furnaces is excessive, and for some reason the crucibles made for them do not withstand the corrosive action of slag to the same extent as the smaller pots. The smelted bullion is cast in bars without any fnrther refining, and has an average fineness of 760.

The cost of precipitation per month, based on the treatment of 4,220 tons of ore, is as follows:

Supervision	£5	0	0
Wages	13	1	3
Power	2	0	0
Repairs	2	7	6
Assaying	8	6	7
Fuel	3	5	10
Zinc (15 cwt.)	70	4	8
Sulphuric acid	4	11	5
Flux, filter-cloth, crucibles and sundries	18	2	1
Total	£126	19	4

or 7·22d. per ton of ore treated.

The Gillies Zinc Process.—The *Australian Mining Standard* for September 27 and October 4 contains a paper by P. M. Gillies read before the Society of Chemical Industry of Victoria describing the Gillies process for the treatment of complex zinc-lead sulphide ores, which is being experimentally tested by the Hydro-electric Power & Metallurgical Company, in Tasmania. The crude ore is coarsely crushed, so as to pass through, say, a ½-in. screen, and is then partly desulphurized, enough sulphur being left in the roasted material to ensure the lead being obtained as sulphate in the subsequent fuming operations. This partly-roasted ore is mixed with an equal weight of carbonaceous material, and charged into a special fuming furnace in which the bulk of the zinc and practically all the lead, with any arsenic, antimony, and cadmium present, are reduced, instantaneously volatilized, and burnt to oxides with an excess of air. The oxides are drawn off from the furnace in the form of fume by means of exhaust fans, and collected by suitable fume-collecting apparatus. The residue or clinker which remains behind in the furnace contains iron, copper, manganese, gold, and silver, with any zinc not volatilized in the fuming process. This residue is smelted, the copper, silver, and gold collected in the form of a matte, and the bulk of the zinc remaining is driven off in the operation and collected in the fume-collecting apparatus. Fume collected by the treatment of a Tasmanian ore is of the following composition: zinc 39%, lead 12·6%, copper 0·46%, gold 4 dwt., silver 13 oz., iron 8·06%, silica 9%, arsenic 0·20%. The constituents were: zinc sulphate 2·8%, zinc oxide 70%, lead sulphate 25·8%, arsenious oxide 0·4%, moisture 1%, no trace of iron or copper. The fume is treated in a special dissolving apparatus, with acidified zinc sulphate solution from the electrolytic section, and the zinc oxide is dissolved, with any arsenic, antimony, or cadmium present. This solution is then allowed to settle, and the clear supernatant liquor drawn off, the precipitated lead sulphate being filtered. This dissolving of the fume is so arranged that the resulting solution of zinc sulphate contains about 1% excess free sulphuric acid, which is hot, due to the dissolving zinc oxide by sulphuric acid. This hot, slightly acid solution is then treated with sulphuretted hydrogen in special apparatus, to precipitate any arsenic, antimony, and cadmium, and the solution is again settled and filtered, by means of a vacuum filter, through porous tiles covered with a thin layer of diatomaceous earth. Finally the purified solutions are electrolyzed, zinc being deposited, and a corresponding quantity of sulphuric acid liberated, the electrolyte being used again to treat fresh batches of fume. Several trial runs, working continuously, have been made with an experimental plant, extending over several weeks, using the same electrolyte in continuous cyclic operation, and from the data obtained, the process is proved capable of economically treating ores of the character referred to at the average prices of metals ruling prior to the war. The products from the treatment of the complex ores from the west coast of Tasmania would be: pure zinc, lead sulphate (which can either be smelted or sold as pigment), copper, gold, silver, and arsenic sulphide. A substance such as gum arabic is added to the electrolyte for the purpose of obtaining a denser and more coherent deposit of zinc.

Potash from Blast-Furnaces.—At a meeting of the Cleveland Institute of Engineers held at Middlesbrough last month, an important paper was read by Kenneth M. Chance on the manufacture of potash in iron blast-furnaces. During the past three years there have been carried out conjointly by the British Cyanides Company, Limited, and the North Lincolnshire Iron Company, Limited, assisted also from time to time by John Lysaght, Limited, an investigation into the production of potash in blast-furnaces and its recovery therefrom. Latterly, under the auspices of the Controller of Potash Production and with the assistance of a number of blast-furnace owners, the scope of the investigation has been considerably extended.

For each 1,000 tons of pig-iron produced in this country there is fed into the blast-furnaces with the ore and coke sufficient raw material to produce from 15 to 30 tons of potash. (The figures given here represented potash as carbonate or chloride). In other words, each million tons of pig iron produced carries with it into the furnaces potential potash to the extent of from 15,000 to 30,000 tons. At the present rate of production of pig iron not less than 200,000 tons of potash is being fed into the blast-furnaces each year. Of this, three-quarters (or 150,000 tons) passes through the furnaces and away in the slags in insoluble form, and one-quarter (or 50,000 tons) is volatilized and carried from the furnaces in the gas in the form of carbonate, chloride, or cyanide, usually a mixture of all three. Of this 50,000 tons, a small proportion is carried down into the dust catchers and down-comers with the heavy dust, and another small proportion is recovered from the stoves and boiler flues, after the combustion of the gas, in the form of sulphate of potash into which it has been converted during the process of combustion. The remainder, which may be estimated as being in the neighbourhood of four-fifths of this 50,000 tons, escapes with the gas up the chimneys and is liberated into the atmosphere. Of all the potash charged into the furnaces, therefore, at the present time, not more than 5% is recovered and of that 5% quite a considerable proportion is thrown away with the heavy dust as having no value.

As a result of recent experiments, two distinct methods have been found for the conversion into a soluble, and therefore recoverable, form of the insoluble potash compounds charged into the furnaces. The first objective was carbonate of potash. The experiments carried out in the blast-furnaces belonging to the North Lincolnshire Iron Company prove that the volatilization in the form of carbonate of potash of the insoluble potash salts charged into the furnace depends directly upon the temperature of the furnace and the proportion of lime to silica in the furnace charge. As these are increased, the production of carbonate of potash increases, but, unhappily, the cost of operating the furnace also appears to increase, and all the evidence up to the present goes to show that after making full allowance for the value of the potash the effect on the cost of pig iron is such that this process cannot be recommended as a commercial method.

A simpler and, according to present information, more economical method of recovering the potash is by adding to the charge an alkaline chloride, of which common salt is the one most readily available. This has the effect of converting the silicates of potash into chlorides, which are volatilized at ordinary working temperatures into the gas in that form, substituting soda for potash in the slags. This method can be relied upon to render available for recovery from 70 to 80% of the potash charged into the furnace, in contrast to the bare 5% now recovered. Since it became known that the addition of salt to the furnace charge is advocated for the production of potash, there has been considerable discussion on the effect which this addition is likely to have upon the linings of the furnaces. Some facts were published by John Pattinson some years ago in a paper read before the Iron and Steel Institute which have some bearing on this question, and the conclusions drawn by him were that the effect of alkali on blast-furnace linings is protective rather than corrosive, in that it forms a glaze on the bricks and thus tends to preserve them. At the North Lincolnshire works nothing has occurred which in any way indicates that the linings are being injured. On the other hand, it has been found that at Skinningrove the quantity of salt contained in the ore and coke that is furnaced there is abnormal, at least as much as would need to be added artificially for the purpose of potash recovery, and the life of the furnaces there is also abnormal in that two are still in blast that were started over twenty years ago.

SHORT NOTICES

Hoisting.—At the meeting of the Cornish Institute of Engineers held on January 5, Henry Nettle, one of the engineers at Holman Brothers, read a paper on Hoisting Operations.

Relining a Shaft.—In the *Iron & Coal Trades Review* for January 25, G. B. Tristram describes the relining of a circular shaft, the brick work at the bottom of which had become broken owing to the pressure of the strata behind.

Electric Light for Mines.—In the *Colliery Guardian* for January 25, L. Fokes writes on the design of low-voltage underground lighting systems.

Re-dredging. — In the *Engineering and Mining Journal* for January 5, W. H. Gardner gives particulars of the re-dredging of alluvial gold ground in California, and discusses the possibility of applying this treatment to the ground of the Oroville Dredging Company.

Dredging for Platinum.—In the *Mining and Scientific Press* for December 8, J. W. Neill describes gold-dredging operations on the Merced river, California, where platinum is recovered as a by-product.

Tin Dredging in Portugal. — In the *Engineering and Mining Journal* for December 29, F. W. Foote and R. S. Ransom give some particulars of the dredging for tin at Guia, Portugal, conducted by the Portuguese American Tin Co., which is owned by Californians.

Copper in Steel. — The January *Bulletin* of the American Institute of Mining Engineers contains a paper by C. R. Hayward and A. B. Johnston on the effect of copper on steel, particularly as regards the influence of small quantities of copper on the mechanical properties of medium-carbon steel.

Mount Cuthbert Smelter.—*The Chemical Engineering and Mining Review* (Melbourne) for November contains an article on the new smelting works of the Mount Cuthbert company, North Queensland.

Reverberatory Furnaces.—In the *Engineering and Mining Journal* for December 22, C. F. Mason writes on the history of the development of side-wall feeding of reverberatory furnaces at the Canadian Copper Co.'s smelter.

Furnace Linings.—The December *Bulletin* of the American Institute of Mining Engineers contains a paper by F. R. Pyne giving information relating to certain disadvantages in the use of chrome linings for reverberatory furnaces used in the metallurgy of copper. These difficulties are in connection with the recovery of metal absorbed by the lining.

Electric Furnace.—The *Engineer* for January 18 describes and illustrates the Greaves-Etchells electric furnace, which is extensively used in Sheffield for the production of alloys and special steels.

Coke in Blast-Furnaces.—At the meeting of the Newcastle section of the Society of Chemical Industry held on January 16, G. W. Hewson read a paper discussing the requirements with regard to the coke used in smelting practice.

Spirlet Furnaces.—*Metallurgical and Chemical Engineering* for January 1 gives some particulars of Spirlet furnaces for roasting blende as used by the National Zinc Company, at Argentine, Kansas. The Spirlet furnace was described in our issue of December.

Zinc Furnace Temperatures.—In *Metallurgical and Chemical Engineering* for January 1, E. M. Johnson continues an article begun in the issue of September 15 on temperatures in regenerative furnaces used in zinc smelting.

Cote-Pierron Zinc Furnaces.—*Metallurgical and Chemical Industry* for January 1 gives some particulars of a Cote-Pierron electric furnace for smelting zinc under construction in Switzerland.

Estimating Bismuth. — In the *Engineering and Mining Journal* for December 22, H. A. B. Motherwell describes a colorometric method of determining bismuth, which has beeu used by the Wallaroo & Moonta and by the Tharsis company.

Precipitation of Gold by Charcoal.—*The Chemical Engineering and Mining Review* (Melbourne) for November contains a description by H. G. Walton of the process for precipitating gold from cyanide solutions by means of powdered charcoal as used at the Yuanmi mine, West Australia.

Ball-Mill Tests. — The January *Bulletin* of the American Institute of Mining Engineers contains a paper by T. C. Van Winkle on recent tests of Marcy and Hardinge ball-mills.

Flotation at Cobalt.—In the *Mining and Scientific Press* for December 8, W. E. Simpson describes local methods of treating the Cobalt silver ores by flotation.

Flotation.—In *Metallurgical and Chemical Engineering* for December 15, M. H. Thornberry and H. T. Mann give their experience with regard to the addition of certain acids and salts in flotation cells, particularly in connection with Missouri lead and zinc ores.

Potash from Blast-Furnace Dust.—The *Journal* of the Society of Chemical Industry for January 15 contains a paper by R. A. Berry and D. N. M'Arthur describing their investigations relating to the recovery of potash from blast-furnace dust.

Potash from Wool.—The *Journal* of the Society of Chemical Industry for January 15 contains a paper by R. S. Weston on the recovery of potash from the liquors in which wool is scoured.

Potash from Felspar.—*Metallurgical and Chemical Engineering* for January 1 and 15 contains a bibliography, prepared by E. C. Buck, of articles, papers, and patents relating to the extraction of potash from felspar and other minerals.

Potash in Nebraska.—*Metallurgical and Chemical Engineering* for December 15 contains a paper by E. E. Thum on the deposits of potash salts on the western edge of the Nebraska sandhills. These deposits are being extensively worked, the output being 350 tons per day containing 25% of water-soluble K_2O, or at the rate of 32,000 tons of K_2O per year.

Graphite.—In the *Queensland Government Mining Journal* for September, B. Dunstan gives an outline of the graphite output of the world, with particulars of uses and markets. There is no production in Queensland at present, though the Mount Bopple district offers inducements to prospectors.

Manganese in Sweden.—*Metallurgical and Chemical Engineering* for December 15 contains a translation of a paper read by J. Harden before a recent meeting of Swedish chemists on Swedish metallurgical practice in the production of manganese alloys.

Tin in Virginia.—In the *Engineering and Mining Journal* for January 5, H. G. Ferguson advocates the re-opening of tin lodes in Irish Creek, Virginia.

Bauxite in Georgia.—The *Engineering and Mining Journal* for January 5 publishes part of a report by H. K. Shearer on the bauxite deposits on the coastal plain of Georgia, and the methods of mining employed.

Sudbury Nickel Ores. — *Economic Geology* for November contains an article by M. A. Dresser on some quantitative measurements of minerals of the nickel eruptive at Sudbury, Ontario.

Missouri Mines.—In the *Engineering and Mining Journal* for December 22, H. W. Kitson commences a series of articles on the lead-zinc mining districts of Joplin and south-east Missouri.

RECENT PATENTS PUBLISHED.

14,156 of 1916 (111,685). W. B. VANDERLIP, London. A concentrating machine comprising a pan having a circular vanning motion and a screw conveyor sunk in a recess in the pan adapted to withdraw the concentrate.

18,329 of 1916 (112,045). T. A. IYER, Bangalore, India. Method of causing molten brass to adhere to iron surfaces.

1,633 of 1917 (112,336). J. H. GILLIES and P. M, GILLIES, Melbourne, Australia. A process for treating complex sulphides. Particulars of this process are given elsewhere in this issue.

1,960 of 1917 (112,338). BRITISH CYANIDES CO. LTD., K. M. CHANCE, E. C. ROSSITER, London, and the NORTH LINCOLNSHIRE IRON CO. LTD., Manchester. Adding common salt to iron blast-furnace charges with the object of obtaining potassium chloride in the dust evolved, the action of the salt being to substitute sodium for the potassium in the silicates contained in the gangue.

3,254 of 1917 (112,199). W. RIDD LE, Middlesbrough. In blast-furnaces and steel furnaces, methods of removing solid metal bottoms.

5,550 of 1917 (112,220). WHITEINCH GALVANIZING CO., Glasgow. A method of coating ship-plates with zinc, on the outside surface only, by painting the other side with lithopone and paris white before passing the plates through the galvanizing bath.

5,782 of 1917 (106,095) and 6,111 of 1917 (112,085). A. CUSQUEL and H. GOUPIL, Paris. A machine for producing metallic powder from molten metal, particularly of aluminium, lead, tin, antimony, and zinc.

7,644 of 1917 (112,377). C. L. JONES, New York. An alloy having the strength of steel, the brightness of silver, capacity to resist atmospheric and acid attacks, capable of being cast and rolled, tough, and suitable for the manufacture of springs, consisting of nickel 67·8%, copper 28%, manganese 2·5%, iron 1·5%, and vanadium 0·2%.

8,550 of 1917 (112,380). M. A. GOLTZ, Winona, Minnesota, U.S.A. The production of thorium pyrophosphate from monazite.

10,072 of 1917 (108,311). ELECTROLYTIC ZINC CO. and H. M. STUART, Baltimore, U.S.A. In anodes for electrolytic baths for the separation of metals in which the anode is surrounded by an envelope of material pervious to the electrolyte but through which the slime, etc., resulting from the disintegration of the anode will not pass, improvements consisting in providing means for maintaining the tight fit of the envelope as disintegration of the anode proceeds.

11,048 of 1917 (110,907). NEW JERSEY ZINC CO., New York. Improvements in bags for catching fume, whereby the caught material is removed from the fabric as soon as possible, thereby maintaining the efficiency of the filtering material.

14,050 of 1917 (112,405). S. L. BERRY, San Francisco. A mechanically-agitated amalgamator for catching gold.

NEW BOOKS.

Mineral Springs of Canada. Part 1. This is Bulletin No. 16 of the Canadian Department of Mines. The authors are John Satterly and R. T. Elworthy, and they deal with the radioactivity of certain mineral springs in Canada.

Spanish By Home Study. By Andres J. R. V. Garcia. London: E. Marlborough & Co. Price: 3s. net, paper covers; 4s. net, cloth covers.

The Phosphates of Saldanha Bay. Memoir No. 10 of the Geological Survey of the Union of South Africa. By A. L. Du Toit. Price 2s. 6d. These phosphate deposits are about 80 miles north of Cape Town.

Iron Ore Occurrences in Canada. Vol. 1. By E. Lindeman and L. L. Bolton. This book is published by the Canadian Department of Mines, and contains descriptions of the principal iron ore mines of Canada. The only producing mines in Canada are the Helen and Magpie, to the north-east of Lake Superior. The Nova Scotia steel industry is based on Newfoundland ores.

COMPANY REPORTS

Mount Lyell Mining & Railway.—This company was formed in Melbourne in 1890 to acquire a copper deposit near the west coast of Tasmania. In 1903 an amalgamation was effected with the North Lyell company owning property adjoining. This amalgamation was advantageous from the metallurgical point of view, as the North Lyell ore, high in copper and silica, makes a good smelting mixture with Mount Lyell ore, which is low in copper and high in sulphur. Under the management of Robert C. Sticht, the system of pyritic smelting has been found perfectly adapted to the treatment of this mixture. The report for the half-year ended September 30 shows that 260,379 tons of ore was raised, as compared with 334,890 tons during the previous half-year. This fall is partly due to a three-weeks strike, and partly to the reduction of the working hours per week from 48 to 44. Of the ore raised, 164,607 tons came from the Mount Lyell, 152,891 tons averaging 0·48% copper, 1·15 oz. silver, and 0·8 dwt. gold being sent to the smelter, and 10,197 tons sent to the acid works; 85,306 tons came from the North Lyell, 82,185 tons averaging 6·68% copper, 1·44 oz. silver and 0·18 dust gold being sent to the smelter, and 3,121 tons averaging 2·94% copper, 0·43 oz. silver and 0·18 dwt. gold being sent to the flotation plant. The flotation plant treated 11,188 tons of ore from the Lvell Comstock mine, and 2,941 tons from the North Lyell, the average content being 2·91% copper. The yield of concentrate was 3,902 tons averaging 9·31% copper, 0·61 oz. silver, 1·2 dwt. gold. The smelter treated 152,668 tons of Mount Lyell ore, 82,878 tons of North Lyell ore, 4,049 tons of concentrate, and 345 tons of purchased ore. The yield of blister copper was 5,832 tons, containing 5,706 tons of copper, 295,126 oz. silver, and 7,455 oz. gold. The costs continue to go up as might be expected owing to the curtailment of operations, and the rise in wages and cost of materials. The cost of mining, smelting, and bessemerizing was 26s. 6d. per ton as compared with 23s. 6d. during the half-year ended September 30, 1916, and 18s. 11d. for the half-year ended March 31, 1916. A new converter plant has been built, and is ready to start directly the necessary linings are received. Experiments have been conducted with leaching in connection with Comstock ore and concentrate. Developments have been continued on the 850 ft., 925 ft., 1,000 ft., and 1,100 ft. levels in the North Lyell with good results. The 1,200 ft. level was flooded during the strike and has not yet been unwatered. The reserve at the Mount Lyell is estimated at 2,013,439 tons averaging 0·5% copper, 1·6 oz. silver, and 0·8 dwt. gold, and at the North Lyell 997,904 tons averaging 6% copper, 1·33 oz. silver, and 0·1 dwt. gold. The accounts for the year ended September 30 show receipts of £962,233, to which is added £41,704 railway traffic revenve, and a net profit of £268,611, out of which £161,150 has been paid as dividend, being at the rate of 12½%.

North Broken Hill.—The report for the half-year ended June 30 last shows that 111,290 tons of ore, averaging 15·8% lead, 13·4% zinc, and 7·9 oz. silver per ton, was sent to the mill. The yield of lead concentrate was 22,045 tons averaging 62·5% lead, 8·5% zinc, and 22·7 oz. silver. Other products were 49,777 tons of zinc tailing averaging 16·4% zinc, 3·2% lead, and 3·7 oz. silver, and 24,353 tons of slime averaging 7·4% lead, 15·4% zinc, and 6·4 oz. silver. The lead concentrate went to the Associated Smelters and the zinc tailing to the Amalgamated Zinc (De Bavay's). The accounts show credits of £332,683, and a net profit of £175,834. The dividends absorbed £120,000, being at the rate of 4s. per share. The working cost per ton, including mining, milling, and development, was 22s. 5d. The main shaft has been sunk from 1,470 to 1,539 ft., and will be continued to 1,620 ft. A new level is to be opened at 1,550 ft. Development on the 1,400 ft. level continues to disclose ore, the assay-value of which is well maintained.

Broken Hill Block 10.—The report of this company for the half-year ended September 30 shows that the output was below normal owing to the strike. The amount of ore treated at the lead mill was 28,428 tons averaging 12·5% lead, 13·1% zinc, and 10·3 oz. silver per ton, and the yield of lead concentrate was 4,322 tons averaging 62·4% lead, 8% zinc, and 34·4 oz. silver. The shipments included 7,254 tons of mill slime averaging 13% lead, 21% zinc, and 15 oz. silver, and 491 tons of vanner middling averaging 19·8% zinc, 5·4% lead, and 8·4 oz. silver. The new flotation plant has been delayed in completion, but by the time this appears, both the lead and the zinc sections should be at work. The receipts were £77,667 and the net profit £28,613, out of which £10,000 has been distributed as dividend, being at the rate of 1s. per £10 share. Development on the 515 ft. and 1,465 ft. levels has disclosed additional ore. Connection is being made on the former level with the workings of the Central mine of the Sulphide Corporation, whereby ventilation will be improved and better facilities for mining the ground provided.

Broken Hill Block 14.—For some years this company has depended for its income on the carbonate ore won from the upper parts of the mine. During the half-year ended September 30 last, 2,933 tons of this ore, averaging 24·03% lead and 11·73 oz. silver per ton, was raised and sold to the Associated Smelters. With regard to the sulphide ore, arrangements have been made to send 1,000 tons weekly to the new flotation plant to be erected by the Block 10 company. Owing to delays in delivery of parts of this plant, and to the scarcity of skilled labour necessary for its erection, the plant will not be ready for some time. A temporary arrangement has, in consequence, been made with the Junction North company whereby 300 tons will be delivered weekly. The company has a 42% interest in the King Island Scheelite Mining Co., which started mining in July. The accounts show an income of £15,467, and a net profit of £1,339, which, added to the balance brought forward, made a total balance of £49,327. Dividends were distributed as follows: £1,500 interest on the 100,000 preference shares of 6s. each, and £5,000 on 100,000 preference and 100,000 ordinary shares, the latter of 25s. each, being 6d. per share.

Amalgamated Zinc (De Bavay's).—This company was formed in 1909 in Australia to acquire the De Bavay flotation process, and it treats the current zinc tailing from the North, South, and Block 10 mines at Broken Hill for the production of zinc concentrate. The Australian patent royalties are pooled with those of Minerals Separation. The report for the half-year ended June 30 last shows that 148,117 tons of material was treated, for a yield of 42,505 tons of zinc concentrate averaging 48% zinc, 6·5% lead, and 9·3 oz. silver, together with 1,217 tons of lead concentrate averaging 55% lead, 11·9% zinc, and 56·3 oz. silver. Zinc concentrate has lately been shipped to America, and at the end of the period under review the amount still to be delivered was 5,000 tons. The stock of concentrate on hand on June 30 was 48,300 tons. The company has a large interest, in association with the Zinc Corporation, in the Electrolylic Zinc Co. of Australia, and when the report was written it was expected that the first unit of the plant would be running in November. The accounts show a profit of £126,672, and £50,000 was distributed as dividend, being 25s. per £1 share.

Knights Deep.—This company belongs to the Consolidated Gold Fields group and was formed in 1895 to acquire property on the dip of the Glencairn and Knights in the middle east Rand. In 1913 an amalgamation was effected with Simmer Deep. The ore is of low grade, but as the stopes are wide, mining is comparatively cheap. The report for the year ended July 31 shows that 1,203,210 tons of ore was mined, and sent to the mill without sorting. The yield of gold was 212,076 oz. worth £886,294, or 14s. 9d. per ton. The working cost was £793,080, or 13s. 3d. per ton, leaving a working profit of £93,214, or 1s. 6d. per ton. After allowing for taxes, and bringing in the balance from the previous year, a credit balance of £160,083 remains. Out of this, £111,528 has been distributed as dividend, being at the rate of 15%. Owing to labour scarcity the tonnage treated was 110,800 less than the year before. The revenue per ton was 4·88d. less and the working cost 1s. higher. The working profit was rather less than half that of the previous year. The ore reserve is estimated at 2,301,000 tons averaging 4·4 dwt., a decrease of 313,000 tons during the year. In addition, partly developed ore is returned at 37,000 tons of an indicated value of 4·32 dwt. There is also a large amount of reclamation ore, complete particulars of which are at present lacking. The decline in the grade of the ore milled during the latter half of the year, together with the increase in costs, has led to some anxiety as to the future of the mine.

Ferreira Deep.—This company belongs to the Central Mining—Rand Mines group, and was formed in 1894 to acquire property on the dip of the Ferreira in the central Rand. Production commenced after the Boer war and excellent dividends have been paid since 1904. The mine has suffered considerably in recent years owing to falls of hanging wall and crushing round shafts. Little ground believed to contain higher-grade ore remains to be developed. The report for the year ended September 30 last shows that 655,608 tons of ore was raised from the mine, and after the rejection of waste, 586,320 tons averaging 8·12 dwt. per ton was sent to the stamps. The yield of gold by amalgamation was 169,632 oz. and by cyanide 60,243 oz., being a total of 229,875 oz., worth £957,972, equal to 7·84 dwt. or 32s. 8d. per ton milled. The working cost was £623,972, or 21s. 3d. per ton, leaving a working profit of £333,999, or 11s. 5d. per ton. The dividends absorbed £281,750, being at the rate of 28¾%. The yield per ton was 2s. 6d. lower than the year before, and the cost was 4d. per ton higher; the tonnage milled was 58,640 less, and the dividends £98,000 lower. The ore reserve is estimated at 604,900 tons in the Main Reef Leader, averaging 7·8 dwt., and 400,600 tons in the South Reef averaging 7·4 dwt., making a total of 1,305,500 tons averaging 7·6 dwt. Of this, 821,500 tons averaging 7·1 dwt. is immediately available for stoping, and the remainder is in shaft and boundary pillars. These figures show a fall of 327,100 tons and 0·7 dwt. compared with those of a year ago. In addition to the stoping reserve, 310,708 tons of ore is in reef packs. This system of reef packing, described in our issue of November last, has proved highly satisfactory for preventing the fall of hanging wall. The western area containing richer ore is fully developed, and there are decreasing numbers of working faces. The eastern area is to be further explored, and certain portions of the Main Reef are to be prospected.

Clydesdale (Transvaal) Collieries.—This company is a subsidiary of the South African & General Investment & Trust Co., and was formed in 1895 under Transvaal laws to acquire the north-western corner of Daggafontein farm in the Far East Rand. The northern half of the property was leased, and finally sold, to the Cassel Colliery Co. In 1904 the property of the Pioneer Coal Syndicate, in the Heilbron district, Orange Free State, was purchased, and in 1914, the coal rights of a portion of the Blaauwkrants farm in the Middelburg district were acquired. The original colliery on Daggafontein was exhausted in 1916, and the Witbank colliery in the Middelburg district started producing in August, 1915. The Coalbrook colliery at Heilbron has been working since 1905. The report for the year ended June 30 shows that 195,949 tons of coal was raised at the Witbank colliery, and 204,325 tons from the Coalbrook colliery, making a total of 400,274 tons. The working profit was £27,074, out of which £6,226 was written off for depreciation, and £9,134 was written off the Witbank development account, thus extinguishing that account. The dividend (No. 17) absorbed £9,250, being at the rate of 5%. The company continues to hold the gold rights on its Daggafontein property; under the existing gold laws, the area would be about 90 claims.

Zaaiplaats Tin. — This company was formed under Transvaal laws in 1908 to acquire lode-tin properties in the Waterberg district north of Pretoria. During the early years large profits were made from rich surface ores. Since then the ore has been of a lower average grade and the veins have been difficult to follow. Some adjoining property was acquired two years ago. During the past year a prospecting campaign by bore-hole has been conducted, on lines laid down by Dr. G. S. Corstorphine. The report for the year ended July 31 last shows that 33,222 tons of ore was extracted from the mine, and this, with 3,003 tons from the dumps, was sorted; after the rejection of 23% waste, 28,132 tons, averaging 1·1% metallic tin, was sent to the mill. There was also treated 8,450 tons of accumulated middling averaging 0·4%. The yield of concentrate was 327 tons from ore and 16 tons from old middling. In addition, 13,452 tons of alluvium was treated for a yield of 12 tons of concentrate, making a total of 355 tons, averaging 70·2% metal. During the year tin smelting was adopted in order to avoid the high freight and smelting charges involved in sending the concentrate to Singapore, and in future it is intended to supply the local market with the metal. The Mauss centrifugal concentrator (described in our issue of February, 1917) has given satisfactory results, though the method of driving has had to be altered. The ore reserve is extremely limited, but development continues to supply ore for the mill, especially in No. 13 section where many rich patches are found. There is also 5,780 tons of old residue to be treated. The accounts show receipts of £39,460 from the sale of concentrate and £6,706 from the sale of metal. The working profit was £950.

KWALL TIN FIELDS OF NIGERIA, LTD.

Directors: E. H. Eldridge, J. P. Rowe, H. G. Latilla. *Secretary:* S. S. Briggs. *Office:* Broad Street Avenue, London, E.C. *Mine Manager:* R. Cousin. *Formed* 1912. *Capital issued:* £41,755 in shares of 5s. each.

Business: The development of alluvial tin ground 12 miles west of Bukeru, Nigeria.

The ordinary general meeting of the Kwall Tin Fields of Nigeria, Ltd., was held on January 17 at Winchester House, London, E.C., Mr. E. H. Eldridge (the Chairman) presiding.

The Chairman, in moving the adoption of the report and accounts, said the accounts showed a profit for twelve months to June 30 last of £5,697, and, this being the first year the company had made a profit, the shareholders might congratulate themselves on so good a start. The amount of tin ore was stated in the accounts at £21,884, of which £10,126 had been realized at the date of the accounts, and £11,758 represented the estimated value of tin in course of transit, taken at £140 per ton; some of it would doubtless realize much higher prices. The output for the year under review was 139 tons as compared with the previous year's output of 68¾ tons. In July last it was found necessary to suspend tin winning for a few months in order to get ahead with prospecting and development, which had for various good reasons got behind. Pitting and boring had to be done to test the ground, so that the manager should know how to distribute his tin-winning labour, and it was essential that advantage should be taken of the rains to sluice off the overburden and get down to the tin-bearing level, and so save the slower and more expensive process of hand labour later on. The manager advised, and was strongly supported by Mr. John M. Iles, that in order to ensure a regular and continuous output a great development effort was necessary. Tin winning had now recommenced, the output for November being 8 tons and that for December 12 tons The manager added in his cable that the non-arrival of pumps considerably interfered with this output. There could not be any doubt that the pumps had now arrived and were at work. They were despatched in November and arrived at Lagos in mid-December, and they might reasonably expect the quantity of tin won would increase forthwith.

The board had been fortunate in securing the servises of Mr. John M. Iles as advisory engineer to the company, His report on the properties was issued to the shareholders in September last, and he was pleased with the company's prospects and the exceptional possibilities of its areas. He stated that there was every indication that developments would prove a large tonnage of tin to exist, and as a guide to his opinion he gave an estimate of 1,019 tons—namely, 119 tons on the Ouree, 400 tons on the Ahoo River, 400 tons on the Danshandon, and 100 tons on the Cameroon. He was careful, however, to state that he thought these figures unfair to their properties and that those of the Danshandon and Cameroon areas were very much under-estimated. Mr. Iles suggested that too much labour should not at present be put on tin winning, but that the larger part of the staff should be devoted to prospecting, and so furnish reliable data for systematically opening up the mine. He thought they should be content for the next few months with a moderate output and so allow the most important prospecting work to go on at the same time. The board realized that it was necessary that prospecting be kept well ahead of development and tin winning, and they hoped to be able to do this in future and also to obtain approximate values of the different areas as soon as convenient.

A résumé of operations had just been received from their manager, Mr. R. Cousin. In the course of his report he said that on the Ouree mining lease of 159 acres various pits and bore-holes were put down and disclosed very rich ground at an average depth of 20 ft. A weir was built, and a leat about half a mile long was cut to bring in water to sluice off the overburden to water level, which averaged about 7 ft. deep over the paddock taken out. Three dams had since been built to conserve the water for the dry season's workings, and various leats cut. A native village, with market, etc., was built, also a camp for one European and a road from Ahoo camp, 2½ miles long, cut. On mining lease of 183 acres acres (Ahoo) a number of pits and bore-holes were sunk and proved payable tin to exist practically the full length of this stream in the lease, which is roughly about 2¼ miles. The flats, although rich, are very small in extent. On mining lease Ahoo 182 acres a paddock was stripped last dry season near the Ahoo native village, with very good results. On mining lease of 67·4 acres (Ahoo) a considerable amount of work had been done—namely, pitting, boring, leat cutting, dam building, blasting out bars across the river, and stripping off overburden. On mining lease of 220 acres in Zaria Province, owing to the insufficiency of water, a leat was cut 1,350 ft. long by 2 ft. wide by 18 in. deep, and a small dam built in the gully to divert the water along this race to connect up to another gully, where a dam 90 ft. long by 18 ft. high was built to conserve the water overnight, but this was also insufficient for ground sluicing, and water from another gully was brought in by a race half a mile long, with an average depth of 2 ft. 6 in. by 18 in. wide. Owing to the unsatisfactory rainy season this year, it has been impossible to work this part of the property with any degree of success. On mining lease of 183·7 acres (Lower Ouree) very little work, in comparison with that on each of the other leases, had been done owing to the scarcity of labour and European staff. A number of pits and bore-holes had been sunk and races or leats cut. With regard to the Danshandon lease of 194 acres which had been applied for, owing to another company having priority over the Kwall Falls, it had not been passed by the Government, but permission was granted to win and ship tin. For the same reason, a lease of 143·5 acres applied for above the falls had had to be withdrawn, as also two mining rights over the Kwall Falls. A lease covering most of the workings on the N'Gell had now been surveyed in the place of the one of 194 acres originally applied for. The application had been sent in to the Government and covered an area of 385·8 acres. A considerable amount of work had been done—namely, blasting a channel in each of the numerous bars of basalt, pitting and boring on an extensive scale, dam building, and leat cutting.

Mr. J. P. Rowe seconded the resolution, and it was carried unanimously.

THE BRITISH BURMAH PETROLEUM CO., LTD.

Directors : Hon. Lionel Holland (*Chairman*), The Earl of Carrick, A. McNab, Major E. Seaborn Marks, Edgar Taylor, Henry C. Taylor. *London Managers :* John Taylor & Sons. *Secretary :* John Ponsford. *Office :* 6, Queen Street Place, London, E.C.4. *Formed :* 1910. *Capital :* £789,191 in shares of 8s. each; debentures £585,598.

Business : Oil production in the Yenangyaung oilfield Burma, with a refinery near Rangoon.

The adjourned seventh ordinary general meeting of the British Burmah Petroleum Company, Ltd., was held on February 8 at the Cannon Street Hotel, London, E.C., the Hon. Lionel Holland presiding.

The Chairman, in moving the adoption of the report and accounts for the year ended last July, said that under all the circumstances they had no reason to be dissatisfied with the results of the year's working. The previous year's statement showed a trading profit of more than £109,000 in excess of the profit earned during the year 1915. They had succeeded in maintaining that position, and, indeed, had improved upon it substantially by a further £39,000 or so. This enabled them to recommend a substantial distribution in the way of dividend to shareholders amounting to nearly £60,000. The debenture debt had also been considerably reduced. A reserve fund had been established, although as yet it consisted for the most part of a reserve employed in the business. The cash position was improving, and, moreover, this year, for the first time, a heavy contingent liability that hitherto existed had been wiped off the balance sheet. In regard to the Rangoon Oil Company—their allied undertaking—when its accounts for the year's working were made up its financial position on March 31 last remained much where it stood at the end of the previous 12 months. There was an increase in revenue of some £5,000. Its debenture issue of 15 lakhs—£100,000—of seven and a-half per cent debentures was successfully completed last February—a year ago—and the loan of the company thereupon extinguished, the liquidator and creditors of the Bank of Burmah accepting debentures in payment of the loan from that bank. The work of the company was mainly concentrated on the Yenangyaung field, and although the deepening of wells on this field to lower oil sands had given some encouraging results, production could only be maintained by a far more extensive drilling programme than formerly. The Twingone area had been so closely worked that the initial yield of wells had been greatly reduced and their yield fell off more rapidly. At the same time, the increasing difficulty nowadays in obtaining delivery of material militated against any substantial addition to a drilling programme, while the cost of a well per foot drilled was materially enhanced. The cost of casing per foot drilled had almost doubled, and the charge for other materials had heavily increased. They had besides to take into account the ever-rising consumption of oil for fuel on the field. The failure—almost complete— of the supply of natural gas on the Twingone reserve compelled them to rely upon oil to provide the power for sinking and for pumping the wells. Some 20% of the gross crude production derived from this territory by the two companies, the Rangoon Oil Company and the British Burmah, some 460 barrels a day, or the output of more than a score of wells, was thus absorbed last year. It involved a serious wastage of crude to the companies that could only continue in growth until a scheme could be carried through for an alternative power to take the place of oil fuel. During the year the proposal for the installation of a centralized electric power plant to avoid this loss and provide a more economical system for working the field had been carefully investigated. The capital outlay needed for such an installation would be considerable, but the resulting economy would more than compensate for the outlay by improving the net production and lengthening the life of the wells.

With the decline in the productiveness of the Twingone field the importance of testing new oil lands became the more urgent, and they were endeavouring, as far as circumstances permitted, to prove and develop certain of their territories outside Twingone. As yet, neither at Singu nor at Yenangyat Block C had the operations given the results hoped for. At Singu the output of the upper oil sands had been disappointing. They were now engaged in proving the deeper sources, but further tests would be needed before they obtained reliable information upon their value. At Block C Yenangyat the wells brought into production gave fair initial yields, but they declined rapidly. They had also begun prospecting work at Myaing, in the Pakokku district, where, although some shows of oil had been met, no sands that would repay exploiting had as yet been tapped. The oil territories held between the two companies—this and the Rangoon Oil Company—on lease or prospecting license outside Twingone and Beme, consisted of 3½ square miles at Myaing, and some nine square miles at Yenangyat, two one square mile blocks of Singu, one mile and various well sites at Minbu, and over two miles at Ngahlaingdwin. In the Twingone Reserve the companies held some 248 well sites, of which 62, of varying promise, were in reserve, and had not yet been drilled, and in Beme, where recently some encouraging results had been reported from deeper sands, they held 103 well sites, of which 75 remained undrilled. The total crude production of the two companies during the period under review was much the same as before, the net production of the Rangoon Oil Company being slightly lower owing to the larger consumption of oil as fuel, for its gross production was practically unaltered, while the gross production of this company was up by some 63,000 barrels, and its net production by some 51,000.

They restarted the manufacture of wax at the refinery, after an interval of more than 18 months, in December, 1916. The methods now adopted had resulted in a marked improvement upon the previous experience, but they expected further advances in throughput and economy when the installation was completed of the new process that had been approved. Generally, their refinery manager was making further improvements in the percentages of recovery, and an independent expert of large experience who visited the refinery during the year reported most favourably upon the intelligence and care with which he was conducting its operations. As compared with the previous twelve months, they had an increased outturn of benzine, but the total daily throughput of crude oil was less than last year—1,662 barrels against 1,736—sales being hampered and reduced by lack of shipping capacity.

Mr. Henry C. Taylor seconded the resolution, which was carried unanimously.

JOHANNESBURG CONSOLIDATED INVESTMENT CO., LTD.

Directors: S. B. Joel *(Chairman)*, J. Emrys Evans, J. Friedlander, J. B. Joel, Isaac Lewis, Sir R. B. Llewelyn, C. Marx, J. Munro, Sir J. S. Purcell, H. A. Rogers, A. R. Stephenson, G. Imroth (*Managing in* South Africa). *Secretary:* W. H. Mardall. *Head Office:* Johannesburg. *London Secretary:* T. Honey. *London Office:* 10 and 11, Austin Friars.

The annual general meeting of the Johannesburg Consolidated Investment Co., Ltd., was held in Johannesburg on November 27, Mr. G. Imroth presiding.

The Chairman, in moving the adoption of the report and accounts, said that for the past two years their permanent chairman, Mr. S. B. Joel, had visited South Africa in order to preside at the meetings of shareholders. He regretted that the difficulty and delay in ocean travelling made it impossible for him to be with them that day. Not only did they miss the benefit of his experience and advice, but also that wave of prosperity which always accompanied his visits to Johannesburg.

Turning to the balance sheet they would see that investments in stocks and shares stood at £3,540,330. An important increase of £632,470 was shown in the book value of the investments under this heading, which represented the cost of new stocks and shares purchased, less the amount of depreciation written off shareholdings and shares realized. This large increase was due to this company having devoted a portion of its resources to the purchase of the controlling interest in the Randfontein Estates Gold Mining Co., the Randfontein Central Gold Mining Co., and the Langlaagte Estate and Gold Mining Co. The control and administration of these companies, once known as the Robinson Group, would be of benefit to their company, and when their affairs had been placed on a sound business footing would increase the dividend-earning capacity. According to their usual custom, the book values of all the shareholdings had been written down to the market value as at June 30, 1917, wherever the former exceeded the latter, and no credit had been taken in the accounts for the appreciation over book cost, which at June 30 last amounted to approximately £1,750,000, and at date was over £2,000,000. The gross profit for the year ended June 30, 1917, amounted to £224,093, a decrease of about £5,000 as compared with the previous year. Against this the expenses, including war donations, staff bonus, &c., amounted to £29,380, reflecting a decrease of about £4,000, leaving a net profit of £194,713 or £1,000 less than last year. To the net profit of £194,713 must be added the amount brought forward from the previous year, £161,344, making a total of £356,057. From this is deducted the sum of £197,500, being the amount of the dividend of 5% paid on September 27 last, leaving a balance of £158,556 to be carried forward to this year's accounts.

At the last meeting their permanent chairman (Mr. S. B. Joel) informed them of the negotiations he was conducting with the other diamond-mining companies and the Government, with a view to restricting and controlling the output of diamonds. They would note from the directors' report that these negotiations were satisfactorily concluded, and the arrangements made had proved eminently successful to all concerned. The diamond industry and all those connected therewith were under a deep debt of gratitude to Mr. S. B. Joel and must heartily congratulate him on the success of his efforts.

Since the date of the last meeting the principle of the inadvisability of the State embarking in mining ventures had been generally accepted. During the year covered by their accounts the Government offered two areas for public tender. They made substantial tenders for both these areas, neither of which was accepted. Since the close of the financial year further leases of Government ground had been offered for tender. The tender of Messrs. Barnato Brothers for one of these leases had been accepted and that firm had offered the company a substantial participation in the business. This offer they had accepted, and they confidently anticipated that the participation in this venture would be most advantageous to the company. It was proposed to form a company with a capital of £1,500,000, the whole of which had been guaranteed. Three hundred thousand (300,000) shares, fully paid up, would be issued at par, and on the remaining 1,200,000 shares 2s. per share would be paid at once, the balance to be called up as required. It had been decided to afford the public the opportunity of subscribing for 150,000 of the fully paid up shares at par.

At the Government Gold Mining Areas mine excellent progress had been made in every direction during the year; the underground position was highly satisfactory, and would become even more so with the introduction of all single shift working about January next. Generally speaking the outlook was most hopeful. The importance of increased development had been kept steadily in view, as would be seen from the fact that for the month of October the payable ore developed amounted to 380,000 tons. The ore reserves at the end of the year would consequently show a substantial increase, as, apart from the increased footage obtained, it was found, when the ore was mined, that the stoping widths and channel widths were higher than previously estimated. Development continued to expose ore of excellent value.

As he had already stated, the company acquired a controlling interest in the Randfontein Central. The ore reserves were published in the company's last annual report as 4,944,302 payable tons, of an average value of 7·8 dwt. The average stoping width over which this value was calculated was not given, but they found that it was 44 in. As this stoping width was being exceeded fairly considerably in practice the consulting engineer made a revision of the ore reserves, after allowing a figure for the external waste in keeping with the actual stoping results, and the result gave 4,955,256 tons, of a value of 6·77 dwt. over 51 in. Every effort had been made to increase these reserves to a figure more commensurate with the size of the Randfontein plant, and it was anticipated that they would show a considerable increase at the end of the present year. For the last three months—that is, August, September, and October—the excess tonnages developed were 87,480, 106,422, and 111,767 respectively. It was pleasing to add that the values in the lower levels of the mine promised well for the future.

After reviewing the position at other mines of the group and pointing out the reasons for reductions of monthly profits under present conditions, the Chairman moved the adoption of the report. This motion was seconded by Mr. Charles Marx and carried unanimously.

NEW MODDERFONTEIN GOLD MINING CO., LTD.

(Incorporated in the Transvaal).

Directors: E. A. Wallers (*Chairman*), W. H. Dawe, J. G. Currey, C. S. Goldman, S. C. Black, R. W. Schumacher, W. T. Graham. *Secretaries:* Rand Mines, Ltd. *Head Office:* Corner House, Johannesburg. *London Secretaries:* A. Moir & Co. *London Office:* 1, London Wall Buildings. *Formed* 1888.

Capital: £1,400,000 in shares of £4 each.

Business: Operates a gold mine in the Far East Rand.

The twentieth ordinary general meeting of shareholders of the New Modderfontein Gold Mining Co., Ltd., was held in Johannesburg on November 28, 1917, Mr. E. A. Wallers presiding.

The Chairman, in moving the adoption of the report and accounts for the year ended June 30, said that shareholders were fortunate in possessing a mine which, like others in the Far Eastern section of the Rand, had a grade of great elasticity. The working profit for the year was £785,017, and there were various items of revenue that brought the final total amount carried to appropriation account to £802,080. The balance brought forward from the previous year was £398,126, and this sum, together with a small amount in respect of forfeited dividends, gave, with the year's results already referred to, £1,200,369 available on appropriation account. Two dividends of, together, 26s. per share absorbed £455,000, taxes £52,481, and capital expenditure £337,982, thus leaving an unappropriated balance of this year of £354,906. The tonnage milled during the period under review was 656,700, an increase of just over 21,000 tons on the previous year; the yield per ton milled was 43s. 4d., as compared with 40s. 10d. for the preceding year; and the working costs per ton 19s. 5d., compared with 17s. 3d. The reason they were able to mill a larger tonnage was that the renovation of the existing reduction plant had been taken in hand and completed. The tonnage handled last year taxed the plant to its utmost capacity, but the value of residue from the cyanide plant had, nevertheless, been reduced from 0·316 dwt. to 0·305 dwt., and the extraction slightly improved. As regards the yield per ton obtained, it was somewhat above the average value of the ore reserves. They were, however, able to do this with ease, because, coincident with the mining operations, they developed a very large tonnage of ore appreciably above the value of the reserves. In addition to this, they again experienced the very gratifying feature that he referred to at the last annual meeting, namely, that on the whole they obtained somewhat higher values from the stoping operations than were called for by the block valuations, an indication that the ore reserve estimates were framed on conservative and careful lines. Of the total ore mined, approximately 83 % came from the ore reserves, and the balance from development faces, etc. An interesting figure to note was that the year's output, measured by tonnage, represented only 7% of the total tonnage in reserve.

With regard to the development work carried out during last year, he had said a year ago that the large development programme then in hand, particularly in the Circular Shaft Section, was to be appreciably reduced at December 31, 1916. Therefore the marked progress in development effected in the company's year now under review was naturally made in the first six months, and it was indeed wise that they took advantage of a good native labour position to push to the utmost extent the new work at that time, as since then, unfortunately, the native labour supply had fallen off greatly. Probably the most important feature in the development work was the continued progress made in sinking No. 2 Incline on the western side of the property. This was deepened 874 ft. to the horizon of the 14th level, which was the present deepest point in the mine. The 13th level was also opened up and driving commenced. The reef disclosures in this area had been quite satisfactory, and before long they would be in possession of a good deal more information in connection with the western part of the mine. This section of the mine was for some time considered to be the poorer side, but the data made available by the work during last year within their boundaries, and the information to be obtained from their neighbours, gave reasonable grounds for anticipating that, on the whole, the western and south-western sections of the mine would be good. On the eastern side development was mainly confined to the 8th, 9th, and 10th levels, and to a smaller degree to the 13th and 14th levels, while numerous winze and rise connections were completed. On the whole, the reef disclosures here were also of quite satisfactory value. The tonnage of payable ore developed in the whole of the mine for the twelve months was 1,419,300 tons of an estimated value of 9·7 dwt. This tonnage was more than double the quantity that was taken from the ore reserves during the year, and therefore the ore reserve position again showed a noticeable improvement. It stood at June 30 last at 8,914,400 tons of an estimated value of 8·5 dwt. per ton over an average stope width of 66 in. The value of the whole of the reserves, therefore, had been increased by 0·1 dwt. in value, notwithstanding the fact that they increased the stope width upon which the ore reserves were estimated by 4½ in. This increase in stope width was due partly to the necessity of making their estimates with the fact in mind that stoping was being carried almost entirely by machines, and also that there was a general tendency in the lower levels of the mine to wider reef channels.

As regards the extension of plant, all the material was on the ground, and the whole of it should be completed and erected just about the end of the year. This plant, however, could not be put into service without the winder and the new compressor plant. The position with regard to the winder was that approximately 60% of its mechanical portion had arrived on the spot, and erection was now taking place. The essentials of the hoists, namely, the drums, had not yet left England, and the latest advices were that it was hoped to ship them within a very few days. The compressor just referred to had been on the water now for about three weeks, and should therefore arrive very shortly. It remained in England five months after completion, which represented the time it took them to obtain an export licence. So it would appear that virtually the only element of doubt was centred in that portion of the winder which had not yet been shipped; as soon as it arrived in this country they would advise shareholders at once, and three months thereafter the winder should be completed.

Mr. S. C. Black seconded the motion, and it was carried unanimously.

NOURSE MINES, LIMITED.

(*Incorporated in the Transvaal*).

Directors: H. C. Boyd (*Chairman*), E. A. Wallers, W. T. Graham, S. C. Black, H. Nourse, E. J. Renaud, A. G. Gill, F. Raleigh. *Secretaries:* Rand Mines, Ltd. *Head Office:* Corner House, Johannesburg. *London Secretaries:* A. Moir & Co. *London Office:* 1 London Wall Buildings. *Formed*, as the Nourse Deep, in 1894. *Capital:* £827,821.

Business: Operates a gold mine in the central part of the Rand.

The twenty-first ordinary general meeting of shareholders of Nourse Mines, Ltd., was held in Johannesburg on November 28, Mr. H. C. Boyd presiding.

The Chairman, in moving the adoption of the report and accounts for the year ended June 30, 1917, said that the policy of concentrating reduction operations at one plant had fulfilled expectations in regard to improving the recovery per ton, and had it been possible to supply the plant with the 50,000 tons monthly which it was capable of treating the profits for the past year would have been materially improved. Unfortunately, since the latter months of the financial year the labour supply had been quite inadequate, and the mine was, in consequence, working at grave disadvantage. The recovery for the year was 28s. 1d. per ton milled; costs per ton rose to 23s. 3d., owing to the reduced scale of operations, expenditure in connection with the alterations and additions at the Deep plant, the increased cost of all supplies, the war bonus and active service and ordinary leave allowances. The working profit was £118,873, an improvement of £4,670. With interest, etc., and after providing for donations, mainly to war funds, and assessment under the Phthisis Act, the net profit came to £117,807, of which the two dividends of 6¼% each absorbed £103,477. Some 20,200 feet of development work was accomplished, and 604,000 tons were returned as developed, of an average value of 6·9 dwt., an appreciable improvement compared with the previous year's results. The disclosures in the Main Reef were again disappointing; some large blocks previously regarded as payable gave disappointing values when opened up, and were consequently removed from the reserves when they were re-estimated at the close of the year. The Main Reef Leader, though continuing to be patchy in the upper part of the mine, showed distinct improvement in the South Nourse Section. The careful following of the narrow pay Leader of the South Reef had resulted in a satisfactory grade of ore being mined from that reef in the Eastern Section of the mine. The ore reserves at 2,160,400 tons of 6·4 dwt. per ton showed a slight reduction in tonnage compared with the previous estimate, but an increase in value of 0·2 dwt. per ton. Owing to the elimination of lower grade ore there was a considerable decrease in the Main Reef tonnage, that retained being 0·3 dwt. higher in value. The South Reef position remained much the same as before, while in the Main Reef Leader there was a marked improvement in quantity and a slight increase in value; this was mainly due to the better disclosures in the South Nourse Section, the average value there having been increased by 1 dwt. per ton as compared with the previous estimate. During the current financial year in view of the shortage of labour every effort had been made to substitute machine for hand drilling, but the monthly tonnage had only averaged a little over 40,000, while recovery had been just under 26s. 5d. per ton, and costs 22s. 10d. Compared with this time last year, there was undoubtedly a noticeable improvement in the position and prospects of the mine itself, and given an adequate supply of labour profits could at once be very materially increased.

Mr. W. T. Graham seconded the motion, and it was carried unanimously.

THE EASTERN SMELTING CO., LTD.

Directors: Sir Ernest W. Birch (*Chairman*), C. L. Budd, Hon. A. R. Adams, S. C. Ambrose. *Local Managers:* Fraser & Co. *Secretary:* F. C. Bell. *Office:* 30 & 31, St. Swithins, Lane, London, E.C. *Formed* 1911. *Capital issued:* £205,000.

Business: Smelting tin at Penang, Federated Malay States.

The sixth ordinary general meeting (adjourned from December 31, 1917) of the shareholders of the Eastern Smelting Company, Ltd., was held on January 14 at the offices, 30-31, St. Swithin's Lane, London, E.C., Sir Ernest W. Birch, K.C.M.G. (Chairman of the company), presiding.

The Secretary (Mr. F. C. Bell) having read the notice convening the meeting and the report of the auditors,

The Chairman said: We held our annual meeting on December 31 and adjourned it till to-day because the accounts were not ready. These accounts, together with the directors' report, have been in your hands, and I presume you will allow me to take them as read. You will see from the cover that one of your directors, Mr. F. J. B. Dykes, is dead. He died quite suddenly from heart disease. He was an old and valued friend of mine, and also of Mr. Budd. His knowledge of tin-mining was of great service to us, and we shall miss his cheery presence at our board meetings. The first item in the accounts to which I call your attention is the property account. It originally stood at £23,201, which figure was arrived at by adding to the purchase price of the property the liabilities of the old company and deducting sundry assets taken over. This account was reduced in 1915 by £3,467 and in 1916 by a similar figure. I am happy to tell you that the balance remaining of £16,181. 11s. 9d. is now written off. The fuel and stores account shows an increase of £13,000. The cost of everything used in our business has increased, especially coal, and you will understand that in a smelting concern large stocks must be kept to insure against emergencies. Notwithstanding the difficulties of transport and the necessity for obtaining licenses to export materials, we have succeeded in keeping our works well supplied with all their requirements. I trust that this may continue.

Turning now to the profit and loss account, I am very pleased to say that the balance of the working account for the year is £53,817, as compared with £24,922 last year. After deducting the items shown on the debit side of this account, there remains a net profit of £49,931 to be carried to the appropriation account. The figure last year was £21,395. This very satisfactory position has only been attained by the loyal and energetic service of all concerned. Messrs. Fraser and Co., our local agents, in the person of Mr. George Penny, have worked untiringly in our best interests, and our works manager, Mr. G. S. Evans, has filled his position with zeal and ability. The whole staff have carried out their duties in a way we much appreciate. When addressing you at previous meetings I have intimated that your directors have had no reason to doubt the prosperous and successful future of the company, and it is a source of gratification to them that they are now able to present such a satisfactory statement to you. If you will now turn to the appropriation account, you will note that, after bringing forward the balance of the last account, £25,017, adding the amount of the profit already mentioned, and allowing for deductions set out in the accounts, there remains a balance to be carried to the balance sheet of £39,691. Out of this sum the directors propose to pay the balance of the preferred dividend for the year—£2,500—and a dividend of 10% on the ordinary shares—£15,500—leaving a net balance unappropriated of £21,691. In regard to the future the directors, in conjunction with the works manager, have constantly in view the adoption of further improvements in our furnace work, and they are hopeful of obtaining substantial working economies therefrom. It is now my pleasure to move that the report and accounts be adopted.

Mr. C. L. Budd seconded the motion, which was unanimously adopted.

The Chairman moved: "That a balance dividend at the rate of 10% per annum for the year ended August 31, 1917, be and is hereby declared on the preferred ordinary share capital of the company, payable on January 21, 1918."

Mr. S. C. Ambrose seconded the motion, which was unanimously passed.

On the motion of the Chairman, seconded by Mr. Budd, it was resolved that a dividend of 10% be declared on the ordinary share capital of the company, payable on January 21.

In moving the re-election as a director of Mr. C. L. Budd, who retired by rotation, the Chairman said he was sure it would be a great satisfaction to all the shareholders to know that Mr. Budd had been created a Companion of the Order of the British Empire in the last Honours.

Mr. Blumm seconded the motion, which was unanimously adopted, and Mr. Budd returned thanks.

The Chairman said that since the last annual meeting Mr. S. C. Ambrose had been co-opted a member of the board. Mr. Ambrose had retired after long residence in Penang, where the company's head works were situated, carrying with him an honourable reputation, and it had been a great pleasure to the directors to be able to invite him and to have him to work with them. He moved Mr. Ambrose's re-election as a director.

The motion was seconded by Mr. Budd and unanimously adopted, and Mr. Ambrose returned thanks.

Messrs. Maxwell Hicks and Co. were re-appointed auditors, and the proceedings terminated.

THE JOHANNESBURG CONSOLIDATED INVESTMENT CO., LTD.

Announces that owing to the irregularity and delay in the mails the issue of the **quarterly reports** to the Shareholders of the **Mines of the Barnato Group** is discontinued for the time being. In place thereof the following is a cabled summary of the quarter's operations.

10 and 11, Austin Friars, London, E.C.2,

January 30, 1918.

Government Gold Mining Areas.
(Modderfontein) Consolidated, Limited.
(Incorporated in the Transvaal).
Report for Quarter ended December 31, 1917.

Tons crushed, 309,900 tons.

		Per ton, based on tonnage Crushed.
Total Working Revenue	£464,815	£1 10 0
Total Working Costs	£290,996	0 18 9
Working Profit	£173,819	£0 11 3
Sundry Revenue	1,524	
Total Profit for quarter	£175,343	

The development footage sampled totalled **6,280** ft., and gave the following results:—**Payable** 4,480 ft., having an average value of **12·7** dwt. over **50** in. of reef. It is estimated that the payable reserves have been increased by over **800,000** tons during the present quarter. Plans and estimtates are being prepared to enlarge the reduction plan by **5** additional tube-mills, with necessary extension to cyanide plant. This addition will bring the crushing capacity up to about **135,000** tons monthly.

Dividend No. 1 of 12½% (2s. 6d. per share) has been declared, payable to shareholders registered at December 31, 1917.

Consolidated Langlaagte Mines Limited.
(Incorporated in the Transvaal).
Report for Quarter ended December 31, 1917.

Tons crushed, 129,150 tons.

		Per ton, based on tonnage Crushed.
Total Working Revenue	£168,469	26 1
Total Working Costs	£122,425	19 0
Working Profit	£46,044	7 1
Sundry Revenue	510	
Total Profit for quarter	£46,554	

Operations were considerably handicapped owing to the continued shortage of native labour. As compared with the previous quarter crushing was decreased by **15,150** tons. Costs were **1s. 10d.** per ton higher. The recovery value was improved by over **10d.** per ton. The Gross Profit was **£11,540** less than last quarter. The development footage sampled totalled **3,632** ft. and gave the following results: **Payable** 1,425 ft, having an average value of **22·4** dwt. over **15** in. of reef.

Dividend No. 9 of 7½% (1s. 6d. per share) has been declared payable to shareholders registered at December 31, 1917.

Randfontein Central Gold Mining Company, Ltd.
(Incorporated in the Transvaal).
Report for Quarter ended December 31, 1917.

Tons crushed, 500,960 tons.

		Per ton, based on tonnage Crushed.
Total Working Revenue	£586,896	23 5
Total Working Costs	489,029	19 6
Working Profit	£97,867	3 11
Sundry Revenue	£3,338	
Total Profit for quarter	£101,205	

As compared with the previous quarter crushing shows an increase of **8,610** tons. Gross Profit shows a reduction of **£10,462.** Shaft sinking accomplished totalled **1,407** ft. The development footage sampled totalled **18,985** ft., and gave the following results: **Payable** 14,695 ft., having an average value of **21·6** dwt. over 19 in. of reef.

Van Ryn Deep, Limited.
(Incorporated in the Transvaal).
Report for Quarter ended December 31, 1917.

Tons crushed, 134,060 tons.

		Per ton, based on tonnage Crushed.
Total Working Revenue	£290,325	43 4
Total Working Costs	£130,298	19 5
Working Profit	£160,027	23 11
Sundry Revenue	5,083	
Total Profit for quarter	£165,110	

Plans and estimates are being prepared for the addition of 10 stamps and a tube-mill, with the necessary cyanide plant. The construction will be put in hand at an early date. The development footage sampled totalled **1,331** ft. and gave the following results: **Payable** 1,262 ft., having an average value of **34·4** dwt. over **20** in. of reef.

Dividend No. 9 of 22½% (4s. 6d. per share) has been declared payable to shareholders registered at December 31, 1917.

Witwatersrand Gold Mining Company, Limited.
(Incorporated in the Transvaal).
Report for Quarter ended December 31, 1917.

Tons crushed, 104,615 tons.

		Per ton, based on tonnage Crushed
Total Working Revenue	£129,274	24 8½
Total Working Costs	93,729	17 11
Working Profit	£35,545	6 9½
Sundry Revenue	4,896	
Total Profit for quarter	£40,441	

The Gross Profit was **£6,776** less than last quarter. The principal reason for the decreased profit is the shortage of native labour. Other factors are the increased cost of imported stores, and the fact that the reef in outcrop section of the Mine is becoming exhausted, making the mill dependent upon the South Section for the bulk of the ore mined. The rock here is much harder than in the upper levels. The development footage sampled totalled **1,560** ft. and gave the following results: **Payable** 770 ft., having an average value of **10·4** dwt. over **41** in.

Dividend No. 27 of **15**% (3s. per share) has been declared payable to shareholders registered at December 31, 1917.

Langlaagte Estate and Gold Mining Company, Ltd.
(Incorporated in the Transvaal).
Report for Quarter ended December 31, 1917.

Tons crushed, 126,660 tons.

		Per ton, based on tonnage Crushed.
Total Working Revenue	£139,929	22 1½
Total Working Costs	£113,673	17 11½
Working Profit	£26,256	4 2
Sundry Revenue	506	
Total Profit for quarter	£26,762	

Owing to a severe shortage of native labour crushing was decreased by **1,820** tons as compared with the previous quarter. Costs were reduced by **11d.** per ton. The grade of the ore milled was **1s.** per ton lower. Gross Profit shows a decrease of **£945.** The development footage sampled totalled **2,344** ft., and gave the following results: **Payable** 1,478 ft., having an average value of **21·3** dwt. over 22 in. of reef.

Dividend No. 54 of **5**% (1s. per share) has been declared payable to shareholders registered at December 31, 1917.

The Mining Magazine

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EDITORIAL

VAGUE announcements have been made recently to the effect that a National Metal and Chemical Bank is to be established in London.

PRECIPITATION of gold from cyanide solutions formed the subject of an interesting discussion at the meeting of the Institution of Mining and Metallurgy held on March 7. We hope to present a general review of the discussion in our next issue.

THE Department of Mines and Industries of the Union of South Africa has done good service to the community by establishing the *South African Journal of Industries.* This monthly paper gives excellent résumés of information relating to the natural resources of the Union. We have already quoted liberally from its pages in the Mining Digest. We hope that its circulation in this country will be actively encouraged.

IN previous years we have been in the habit of reviewing the gold output of the world in our February or March issue. This year the statistics are coming in so slowly, and general information on which to base estimates where no official figures are available is so scarce and unreliable, that we are obliged to postpone our statement for 1917. In general terms it may be said that the Transvaal output shows a slight decrease, and that the productions of the United States, Australasia, Russia, Rhodesia, and West Africa have substantially fallen.

NO better example of the absence of system in British mining matters, to which reference is made on a succeeding page, could be provided than by the fact that the pamphlets on the iron and zinc ores of the world are issued independently and by different organizations. That on iron ores was prepared at the instance of the Department of Scientific and Industrial Research, and that on zinc ores by the Mineral Resources Committee of the Imperial Institute. We extend a welcome to a second edition of the Iron Ore pamphlet, for it contains several necessary corrections and additions.

NOWADAYS, with the Treasury controlling new issues of capital, there is a tendency on the part of City people to boast that mining exploitation conducted under its auspices is a perfectly honest business. Mining is, of course, a genuine basic industry, as it provides the metals and minerals desired by the community. But in the City the production of the mines counts as nothing as compared with the financial uses to which the shares of a mining company can be put. In these respectable times, it is well to draw attention to follies committed in the name of mining, due to ignorance of the principles of engineering, or to the desire to deceive the incautious investor. For this reason the article by Mr. John McCombie, an old and experienced mine manager and metallurgist, appearing in this issue, may prove helpful to both the promoter and the public.

THE current issue of the *Bulletin* of the Imperial Institute contains a timely exposition of the constitution and work of the Institute in connection with the mineral resources of the Empire. The Institute started on its career under the best of auspices but in those peaceful and spacious days nobody cared about the commercial and industrial resources of the Empire, and the scheme nearly died of inanition. Nevertheless many good men, well versed in research and the collection of statistics, have done creditable work for the Institute, and their experience should now be utilized in the formation of an Imperial bureau of information. This is the chance for the Imperial Institute to make good, and the authorities should give it the opportunity.

WE notice that the American Institute of Mining Engineers is proposing to modify its rules relating to membership, whereby entrance shall be more severely regulated than before. At the same time the council points with pride to the fact that 1,023 new members were elected in 1917. The accession of so many members in one year is an indication that the conditions were not onerous. It is a pity that a society of 47 years standing should, after a period of special freedom of admission, suddenly raise the standard, for such a modification of policy is not fair to the profession or to the rising generation. Another criticism that we have to offer is that the Institute continues to make a specialty of the metallurgy of iron and steel, though an American Iron and Steel Institute was formed some years ago. It seems out of place for Professor H. M. Howe's paper on the erosion of guns to be published in the Bulletin. The Institute will be well advised to restrict its scope to the non-ferrous metals and oil.

WRITERS of romance occasionally prophesy better than they know. For instance, as Mr. W. H. Thorpe reminds us in *Engineering*, Dr. Johnson laid down in "Rasselas" the main principle of aviation when he said: "You will be necessarily upborne by the air if you can renew any impluse upon it faster than the air can recede from the pressure." A more specific prophecy, but spoken in jest, was that of Swift in "Gulliver's Travels," where he recorded that the astronomers of Laputa had discovered two satellites of Mars; "whereof the innermost is distant from the centre of the planet exactly three of his diameters and the outermost five; the former revolves in the space of 10 hours and the latter in 21½." It was only in 1877 that these satellites were discovered by our astronomers, who found that the inner moon is at a distance equal to 1½ times the diameter of the planet and the outer at a distance of 4 diameters; while the periods of revolution are 8 hours and 30 hours respectively.

The Excess Profits Tax.

A notable concession has been granted to mining by the tax assessors, for they have recognized that tin lode operations in Cornwall should receive 25% profit before excess profits tax is levied. That level fairly accurately represents the view of the wise investor in mining shares. Another evidence of reasonableness on the part of the Government, but of a different nature, is provided by the agreement made with East Pool & Agar. As our readers know, this company has developed a bonanza, or, as it is called in Cornwall, a carbona, which amply compensates for the low-grade complex ore found elsewhere in the mine. Good mining demanded that rich and poor ore should be so extracted as to make it possible to recover the maximum amount of metal. Such a policy also reduced the heavy burden imposed by the law that considers the whole of the profits of a company arriving at the profit-earning stage as "excess profits" after a certain maximum is exceeded and taxes them accordingly. When the Munitions Department called for more tin, and asked East Pool to adopt the policy known in mining parlance as "gutting" the mine, the directors and shareholders looked for some financial off-set. It has proved impossible to move the tax-gatherers, and, instead, the relief has come from the Ministry of Munitions. According to the agreement made between the company and the Munitions Department, the company is to double its output, and the net earnings accruing from the additional amount of concentrate produced, as compared with the output for 1917, is to be invested by the company in Government securities. These funds may be applied for the purpose of providing additional working capital, and, after the war, new fully-paid shares may be issued against such funds whether still invested in these securities or spent on improvements on capital account. The Ministry of Munitions undertakes to pay to the Inland Revenue the part of the excess profits duty that would be payable on the profits accruing from the increased output. This arrangement is, up to a point, advantageous to the shareholders, but the method of shifting the incidence of the excess profits tax is unsatisfactory and contrary to the best principles of political economy, in that it proves nothing and can form no precedent of value in the theory and practice of taxation. What is wanted is the just recognition of the value of new enterprises, or old enterprises coming to the profit-earning stage, by placing them on an equal footing with the old-established companies in regard to the taxation of excess profits.

Petroleum Prospects in Great Britain.

During the last two years much inquiry has been made with regard to the chances of finding petroleum in the United Kingdom in commercial quantities. Mr. Forbes-Leslie has published a paper on the known occurrences, and he has indicated favourable spots for drilling operations. On the other hand, Mr. W. H. Dalton has expressed his disbelief in the hopeful theories and has thrown a cold douche on the proposals. Now comes Lord Cowdray with a definite offer to spend money liberally on a systematic scheme of investigation, provided the Government protects the position. Lord Cowdray, as head of the Pearson oil interests in Mexico, is fully posted on the economics of oil production, and should also be capable of judging as to the reliability of his technical and geological advisers. His readiness to back his opinion by an extensive financial outlay is evidence of his belief in the possibility of establishing a petroleum output in this country and his trust in his advisers. We cannot do better than quote from the statement which he has circulated publicly.

Extensive studies on the part of his scientific staff during the last 3½ years lead to the conclusion that, notwithstanding the long-established opinion to the contrary, the possibilities of securing a commerical production of oil in Great Britain are of a distinctly promising nature, and advice to that effect has been given from time to time to the Admiralty. In June last he was approached by the Admiralty with a view to his undertaking immediate drilling as a war measure, but as he was not at the time in possession of sufficiently extensive leases, nothing could be done. He urged then, and still urges, that a properly organized scheme should be adopted on a national scale so that capital and the oil resources shall not be squandered, and that the many evil results of uncontrolled drilling and output shall be avoided. Experience in America has shown him that the policy of uncontrolled working and of such working on small areas has been a blunder. Moreover that method has produced wild speculation and has resulted in deplorable waste. A national system of drilling properly apportioning the areas would obviate these many wastes. The community would be the gainers and the resources of oil would be conserved. Lord Cowdray's firm has submitted two proposals for operation under such a national scheme. According to the first, the firm's services and those of its geological staff would be given free of charge for the period of the war for the purposes of exploration and development. The second proposal is that, should the Government not care to risk public money in the enterprise, the firm is prepared to conduct drilling operations at its own risk and expense as licensees, subject to certain areas being reserved to it, the amount to which the firm was committed under this offer being something like half-a-million pounds. The Government, however, has not accepted either proposal, but suggests instead that work shall be done at the public expense, without legislation, and under the Defence of the Realm Act. According to this plan the benefit of the national expenditure would revert after the war to the owners of the land. Even if the nation subsequently agreed to purchase the land, it would have to pay for it at the enhanced value due to the proved presence of oil, a proceeding which would not be fair to the community. Whether or not a royalty should be paid to landowners is an item of small importance. What Lord Cowdray is fighting for is legislation which will obviate the disastrous small-block system and wilfully control the entire extent of any oil-pool discovered. It seems a pity that departmental prejudice and red-tapeism should stand in the way of a capitalist prepared to risk money, provide expert geological advice, and conduct an extensive drilling campaign. Such an opportunity to prove or disprove the various theories and arguments does not occur often. We give this full publicity to Lord Cowdray's proposals because they are based on sound principles and because they provide the much desired opportunity for testing the possibilities of finding oil in the United Kingdom; though we cannot refrain from wishing that he would give the technological reasons for taking such a sanguine view of the possibilities.

A Department of Mines.

Among the many lessons taught by the war is the necessity and desirability of appreciating intelligently the mineral resources of the United Kingdom and the British Empire. In the past, commercial considerations alone have ruled the choice of the sources of our supplies of metals and minerals. All the world has been our storehouse. To use a threadbare phrase, the object of mining was to make a profit. The war has drawn attention to the fact that the real object of mining is to obtain minerals and metals out of the ground that are serviceable to man. Supplies from enemy countries are suspended, arrivals from our Overseas Dominions and from friendly countries are liable to loss owing to submarine attack, and the scarcity of shipping gives rise to fatal delay in delivery. Thus the immediate vital problem is to seek for home supplies, and the policy for the future is to study and develop the resources of the Empire. The war had progressed for many months before this aspect of the situation was duly appreciated, but during the past two years the position has been recognized, and those in authority have worked with the utmost vigour with the object of utilizing our home resources. But, as usually happens when organizations are established hurriedly, a great deal of overlapping of different departments occurs, and the activities of various committees and institutions are not employed to the best advantage owing to the entire absence of a central control. In times of stress, only immediate requirements receive attention, and there is no time for a calm and judicious coordination of effort. Moreover work is often delegated to a new committee that might, if the controllers had wider knowledge and sympathy, be undertaken more efficiently by an existing organization, though as a rule the societies and institutions that have proved themselves capable in the past have received recognition.

For some time efforts have been made to devise a plan whereby all these researches and investigations may be made a permanent feature of our polity. Expressions of opinion are courted and advice is invited. For this reason we take the opportunity of expressing our views. To begin with, nothing of real value can be done for the benefit of the mineral industry of the United Kingdom until the Government accedes to the general demand for the establishment of a Department of Mines. It is now eighteen months ago since our four leading institutions, the Institution of Mining and Metallurgy, the Institution of Mining Engineers, the Iron & Steel Institute, and the Institute of Metals, formulated a proposal on these lines, but with an unnecessarily limited scope. In itself this proposal exemplified the absence of system to which we have alluded, in that the petition had to be addressed to a specially constituted war committee, namely the Committee of the Privy Council for Scientific and Industrial Research. For ourselves we would greatly enlarge the scope of the department proposed by these four societies, not confining its duties to the collection of information, but including within its sphere the supervision of the administration of mines in the United Kingdom, and thus making it a real Department of Mines. To appreciate the need for such a drastic reorganization it is only necessary to mention the way in which mining interests are split among various Government departments at present. To begin with, the Government supervision and inspection of mining operations is in the hands of the Home Office, as also is the collection of statistics of production and the publication of lists of mines operating and abandoned. Then the Geological Survey is under the Board of Education, while the preparation and issue of the memoirs and maps are in the hands of the Ordnance Survey, which is a branch of the Board of Agriculture and Fisheries. The Imperial Institute, which does so much in the collection of commercial information relating to metals and minerals, and in scientific and technical research, is in the control of the Colonial Office. We have already mentioned the Committee of the Privy Council for Scientific and Industrial Research. Lastly comes the department for the development of mineral resources, a branch of the Ministry of Munitions, which, under the presidency of Sir Lionel Phillips, is actively investigating the ore deposits of this country from the mining engineer's point of view. The mere recital of these various disjointed activities is sufficient to suggest the remedy, namely, the collection of the many fragments, and their welding into a harmonious whole. The department at present forming a unit of the Home Office should undoubtedly be the structure to which the others would be attached. The transfer of the Geological Survey would cause no difficulties, and though the Ordnance Survey would naturally continue to prepare the geological maps, there is no reason why these and the other publications of the Survey should not be officially issued by the new department. As regards the Imperial Institute and the Committee of the Privy Council, only those sections should be transferred that refer to metals and minerals. We believe that the organization and personnel in connection with these two bodies is sufficiently good to provide the basis of the sections of the new department devoted to the collection of statistics and other information, and to mineralogical and chemical investigations, though the staff coming from the Imperial Institute would have to be improved by the inclusion of men having more experience in the field. Sir Lionel Phillips' committee, though purely a war measure, would assuredly work to great advantage afterward, acting in the nature of a complement to the Geological Survey and adding the experience of the mining engineer in economic geology, a branch of the science on which the Survey is not strong at present. One of the most important future functions of the committee, acting in conjunction with the Survey, would be to provide geological advice for the many owners of small properties who are financially unable to commission eminent experts. There is also another duty that a Department of Mines could undertake, namely, the investigation of the schemes put before the public for subscription of capital for mining undertakings. At the present time, mining as directed from the City of London happens to be a comparatively honest business, for no new capital issue can be made without the consent of the Treasury. Would not the continuance of this rule after the war be of advantage to those connected with mining? But the present protection is not by any means perfect, for puffs of doubtful nature are still being circulated with regard to home and overseas ventures. The recipients of such invitations should have the right, and should consider it their duty, to make inquiries of a Department of Mines. Moreover, shareholders in existing companies should have the right not only to have an investigation made of a property involved in a new deal, but to have the terms of the purchase by the board fully disclosed.

The question is also asked whether any improvement can be made in the relations between the mother country and the Overseas Dominions in the matter of the supply of metals and minerals. Any improvement in this direction will be easily accomplished when a Department of Mines has been established in this country on the lines indicated. It is not for us to suggest alterations in the methods pursued by the Overseas Dominions. Canada and Australasia are liberal in help to the mining industries. South Africa is sufficiently alive to the public advantage accruing to the community from mining operations. As the house most requiring to be set in order is that of the United Kingdom, any criticism, coming from this side, of the methods adopted in other parts of the Empire, and any suggestions for the coordination of the interests of the Empire in connection with the metal and mineral industries, are out of place on our part at present. The relations between the Mines Departments of the Overseas Dominions and a real Department of Mines in the old country on the lines here sketched would rapidly and almost automatically adjust themselves.

The Iron Resources of the Empire.

Last month we briefly reviewed the coal resources of the Overseas Dominions, and it is suitable to follow that statement by an outline of deposits of iron ore within the bounds of the Empire. It may be said at once that our iron resources are not so extensive or important as those of coal, at least as ores are judged to-day or in demand for the present systems and methods of treatment. The only ore supplies forming important bases of steel production are those of Newfoundland, India, and South Australia, with minor sources in Canada and New South Wales. It is doubtful whether any of these with the exception of those in Newfoundland can compare with the deposits of Spain, Lorraine, Sweden, South Russia, Brazil, and the Lake Superior district. There are throughout the Empire many other iron ore deposits which cannot be exploited profitably at present, for one reason or another. We believe that no iron ore from the Overseas Dominions, except small consignments from Newfoundland, has ever been imported into this country.

The deposits in Newfoundland are known as the Wabana mines, and they are situated on Bell Island in Conception Bay, not far from St. John's, the capital. The beds dip flatly under the sea. They are of sedimentary origin and are contained in a series of sandstones and shales of Ordovician age. There are three workable beds, 6, 8, and 16 ft. thick respectively, and the ore, classed as hematite, averages 50 to 55% iron, 10% silica, and 0·8% phosphorus. The high phosphorus content renders the ore unamenable to the bessemer process. As regards the extent of the deposits, the estimated figures lie between 3,000 and 4,000 million tons. Two Canadian companies are operating these mines and smelting the ores, namely the Dominion Steel Corporation and the Nova Scotia Steel & Coal Co., both having their blast-furnaces, steel furnaces, rolling mills, etc., at Sydney, Cape Breton Island. The latter company has also shipped ore to Philadelphia, Germany, and England. Compared with the Wabana deposits, the producing mines in Canada are of minor importance. At the present time only the siderite at the Magpie mine and the hematite at the Helen mine, both in north-western Ontario, are being smelted, and the latter is on the verge of exhaustion. The owner of these properties, the Algoma Steel Corporation, relies almost entirely on ores from the other side of Lake Superior in the United States for the supplies for its blast-furnaces at Sault Sainte Marie.

The notable iron ore deposits in South Australia are known as the Iron Knob and Iron Monarch, and are owned and worked by the Broken Hill Proprietary, the blast-furnaces and steel plant being at Newcastle, New South Wales, adjacent to the coalfields. The Iron Knob ore is a high grade of hematite, and that at Iron Monarch is a hematite containing manganese. The deposits are rich but comparatively limited, the estimated total amount of available ore being about 20,000,000 tons. The importance of the Proprietary's enterprise from a national point of view can hardly be exaggerated and its benefits to Australia will be increasingly great. The other iron-smelting centre in Australia is Lithgow, New South Wales, where the Eskbank Iron Works treats ore from Tallawang and Coombing Park. About 90,000 tons of this ore was smelted during 1916.

The credit for the development and utilization of Indian deposits is to be awarded to the Bengal Iron & Steel Co. and to Mr. Jamsetjee Tata, the latter's enterprise being much the more important. Mr. Tata is a Parsee merchant whose shrewdness has brought him success in several lines of industry and this example of native talent is a matter for congratulation. His technical advisers have been Americans, of whom Mr. C. P. Perin as metallurgist and

Mr. C. M. Weld as mining geologist deserve particular mention. It happens that on another page of this issue we print a historical account of the Tata enterprise. The chief supplies for the Tata furnaces come from Gurumaishire, in the native state of Mourbanj, about 200 miles west of Calcutta, and the Bengal company obtains its ore from mines in the state of Singhbum, Bengal, in practically the same geological district.

In the foregoing paragraphs we have given an outline of the successful ventures, and we will now turn to the deposits which may on future occasions provide sources of supply. As regards Canada, a bulletin recently published by the Department of Mines contains much information relating to known deposits. Throughout Ontario, Quebec, New Brunswick, and Nova Scotia there are deposits of hematite, magnetite, and laterite. Some of these have been worked in earlier days, but none of them appears to be sufficiently extensive or rich to provide a base for a modern smelting industry. In British Columbia, magnetite deposits are found in the coastal districts and in the adjacent islands that might be smelted on a small scale, but the grade is low and the presence of sulphide minerals is an objectionable feature.

South Africa contains many deposits of hematite and magnetite of potential importance. In recent years Mr. F. W. Harbord has reported for the Transvaal Government and Dr. F. H. Hatch for the Natal Government on the possibilities in this direction. In our issues of July, 1910, and April, 1910, respectively we gave outlines of the information and opinions contained in their reports. Briefly stated Mr. Harbord drew attention to the magnetic quartzites at Timeball Hill near Pretoria, and in the Airlie district, and to the hematite beds south-east of Middelburg. None of these deposits is of the highest grade. Though extensive they are not big enough or sufficiently developed to make Mr. Harbord throw caution to the winds. It is interesting to note that the Timeball Hill deposits are receiving renewed attention, as recorded in our issue of November last. Dr. Hatch reports the existence of many beds of silicious hematite and of laterite, some of them extensive though usually thin. Though not able at the time to recommend the establishment of a smelting industry he does not bang the door in the face of hope. Silicious hematite deposits are known in Bechuanaland and in the northern parts of the Cape Province. Mr. F. P. Mennell has written of similar deposits in Rhodesia. The laterites of West Africa are extensive and are sufficiently high in iron to be used as ores, as was recorded in our last issue by Captain S. F. G. White. Whether any systematic use of such ores could be made remains to be seen.

Lastly we come to Australasia. We have already mentioned the deposits worked by the Broken Hill Proprietary and by the Lithgow smelter. Other deposits besides the Iron Knob are known in South Australia, notably those at Cuttna and Mount Jagged. These appear to have been used so far only as fluxes in the smelting of copper. In New South Wales, Mr. J. B. Jacquet has recorded 200 deposits, of which those at Coombing Park and Cadia impressed him the most. Dr. J. W. Gregory has described the occurrences in Victoria, of which the silicious limonite near Ballarat is the most interesting, though the chances of its employment are small. Another deposit is a high-grade hematite at Buchan. Queensland has many deposits of iron ore, and as we mentioned in the December issue, the Government comtemplates erecting a furnace at Biggenden, where half a million tons of high-grade hematite is developed. New Zealand has two deposits of some promise, one of limonite at Parapara near Nelson, at the north of South Island, and the other consisting of titaniferous magnetite sands on the coast round Mount Egmont, in North Island. Experimental smelting of the latter ores is at present being undertaken. But perhaps the deposits in West Australia are the most interesting, for they are rich and extensive, though quite undeveloped and not even surveyed. It is obvious that their isolation from adequate coal resources makes the problem of their utilization well-nigh insoluble. The deposits at Wilgi Mia, Mount Lulworth, Mount Hale, and Gabanintha, all in the Murchison district, would delight the heart of the iron master if they were situated within his reach, for millions of tons of hematite are ready for extraction averaging 65% iron or over, not more than 1% of silica, and mere traces of phosphorus and sulphur. In what way these deposits can be made useful is not quite clear.

It will be seen from this brief review that our resources of presently acceptable iron ores are not very extensive. Of all the sections of the Empire, India appears to provide the best chances for systematic exploration, and we have no doubt that the geologists have the matter well in hand. The Tata firm owns other rich deposits, at Rajara and Dullel in the Central Provinces, of which more will be heard later. We hope on another occasion to say more of the Indian iron ore resources.

REVIEW OF MINING

Introductory.—The utter collapse of Russia, the annexation of Russian territory by Germany, and the rapid spread of German influence nothward and eastward are having depressing effects in England, and the Eastern outlook is shrouded with doubt. Mining and metallurgical operations become increasingly difficult, with the rises in wages and in cost of materials, and with the scarcity of men and stores. A notable concession on the part of the taxing authorites comes to Cornwall, where 25% has been fixed as the standard from which excess profits are to be calculated. The similar figure for West African gold mines has been fixed at 22½%, and that for British India also at 22½%. The latter does not apply to operations in Mysore, which is a Native State. In the tin market, scarcity of supplies has forced prices up again. Voluntary rationing is being tried on the Metal Exchange, but it is felt that Government control will have to come eventually.

Transvaal. — The output of gold on the Rand during February was 637,571 oz., and in outside districts 22,188, making a total of 659,759 oz. worth £2,802,477, as compared with 694,121 oz., 19,991 oz., 714,184 oz., and £3,033,653 respectively during January. As explained elsewhere, the cause of the drop has been the severe rainfall and flooding of many of the mines. The number of native labourers at the gold mines at the end of February was 181,066, as compared with 176,404 at the end of January, and 191,095 at the end of February, 1917.

The floods on the Rand have done more extensive damage than was anticipated at first. Particulars have already been given of the flooding of the new shafts at Brakpan and Daggafontein. The rains early in the season were exceptional, during the 14th and 15th of February the fall was severe, and since then there have been heavy local showers. At many mines throughout the Rand, hoisting plant had to be given the duty of bailing, so that the tonnage raised and treated during February shows a marked decrease.

As recorded in our December issue, the West Rietfontein property was put up on offer again by the Government, with the stipulation that it must be worked as an independent concern and not in conjunction with neighbouring properties. Four tenders have been received on the new basis.

The transfer of the leases of the Springs-South Geduld area from Barnato Brothers to the New State Areas, Limited, was made at the end of February. Of the 1,500,000 shares in the new company, 150,000 are being offered to residents within the Union for subscription at par, £1. The mining programme calls for the sinking of two vertical shafts calculated to cut the reef at about 3,600 ft.

It will be remembered that in the latter part of last year the Mines Department provisionally agreed to modify the lease of the Government Gold Mining Areas in order to remove some of the anomalies of a crude formula. Particulars of the old and new formula were given in our November issue. On bringing the matter before the Union Parliament, unexpected opposition arose, and the proposals were referred to the Public Accounts Committee. This committee is also averse to the modification, so apparently the company will have to abide by the old contract. All we can say is that it is a pity the politicians have gone counter to the Government's expert advisers.

The Sheba Gold Mining Co. is to suspend operations, for the duration of the war at any rate. For some months losses have been made owing to high costs and poverty of the ore. As we recorded in our January issue, the amount of payable ore has been diminishing rapidly lately. Both the consulting engineer, Mr. C. B. Kingston, and the manager, Mr. J. T. Milligan, point to certain sections that would be well worth prospecting and developing, but the funds required for such work would amount to £20,000, and the board does not see its way clear to find such a sum. Operations are therefore to be suspended, and the mines will be kept in good order in the hope that the opportunity will arrive for them to be reopened.

The Messina (Transvaal) Development Co. has received notification that it will not be permitted to continue shipping copper concentrate and matte to this country. The company will therefore have to erect a converting plant and extend its smelter. The recent developments at the mine have disclosed ore of much lower grade than formerly.

Diamonds. — The output of diamonds throughout the Union of South Africa during 1917 is reported at 2,902,416 carats valued at £7,713,810. The sales amounted to 2,419,209 carats valued at £6,170,906.

Elsewhere we give an outline of the yearly report of the De Beers Consolidated, just published. More recently the report of the Premier company for the year ended October 31 has come to hand. During this time, 4,928,629 loads were washed for a recovery of 906,341 carats, being 0·184 carat per load. The profit for the year was £757,045, of which £454,227 accrued to the Government. The preferred shares received £246,250, of which £200,000 was arrears accumulated during the period of idleness, and the deferred shares £100,000.

Rhodesia.—The output of gold during January was worth £253,807, as compared with £270,616 in December and £296,113 in January, 1917. The fall in the yield has been continuous during the last six months, owing to many of the smaller mines closing or curtailing operations under adverse war conditions. Other outputs of Southern Rhodesia for the month were: silver 16,215 oz., copper 308 tons, coal 45,740 tons, chrome ore 4,463 tons, asbestos 400 tons. It has to be remembered that these official figures relate to Southern Rhodesia only. This is a pity, for the results at Rhodesia Broken Hill, one of the most interesting of recent ventures, are thus omitted. The output of lead at this property for January was 949 tons, and for February 812 tons.

Communication between Rhodesia and the coast at Beira has been severed by the demolition of several bridges and the flooding of the railway line a tvarious points owing to torrential downpour. Unprecedented deluges have been experienced throughout Portuguese East Africa, Zululand, and Natal, as well as on the Rand, the results of which are recorded elsewhere.

The Selukwe Columbia company announces that its mines, the Wonderland group in the Gwelo district, are to be closed down at the end of this month owing to losses in working, unfavourable developments, and the increased cost of stores. Attempts will be made to let the property on tribute.

West Africa.—The Board of Referees in London has fixed 22½% as the statutory percentage for the purposes of excess profits duty in connection with gold mining companies operating in West Africa.

The output of gold in West Africa during January was worth £107,863, as compared with £122,602 in December and £131,665 in January a year ago. Part of the drop is due to the Ashanti Goldfields figures being £7,000 below normal owing to the fall of ground mentioned in our last issue. Another cause is the serious reduction in the yield per ton at Abbontiakoon from 45s. 5d. in December to 26s. 11d. in January, thus accounting for a decrease in the output from £20,330 to £12,648. We are informed, however, that this fall is more apparent than real, and that it is due to an incomplete clean-up at the tube-mills.

Nigeria.—The New Lafon Tin Fields is a company that has had a hard fight for existence. A year or more ago additional properties were bought, and they have been paid for out of the revenue derived from them. Additional ground is now being acquired, and, for the purpose of purchase and operation, money to the amount of over £11,000 is being advanced by parties who will take the remainder of the unissued shares, 92,593, having a par value of 2s. each, whenever the Treasury sanctions the issue. Mr. A. A. Davidson, the manager, reports that the area proved measures 300 by 250 ft., and averages 4 lb. per yard for a depth of 8 to 10 ft. The ground adjoining is also promising.

Australia.—Our Melbourne correspondent sends us an instructive review of the labour position.

The rise in wages and the cost of stores, coupled with the shortness and inefficiency of labour, continue to threaten the mining industry. The Sons of Gwalia, at Leonora, has had to pass its usual quarterly dividend, as the exact position as to profits cannot be determined, and consideration of a distribution is postponed until the end of the company's half-year in June.

The Ivanhoe, at Kalgoorlie, also has to report the adverse effect of present conditions. The cost of materials and labour has advanced, and the scarcity of efficient labour has made it necessary to reduce the tonnage mined. But this is not all, for Mr. John McDermott, who was appointed manager a few months ago, has reported that his estimate of the gold content, at 34s. 2d., is 2s. 1d. less than the figure of a year ago. The reserve is given at 1,035,000 tons, sufficient to last for four years. The prospect of finding additional ore at depth is remote, though on the other hand lateral exploration in the upper levels may disclose ore. The directors warn shareholders to expect from now onward a monthly profit of £5,400 instead of the £9,000 to which they have been accustomed recently.

The position at Kalgoorlie is seriously imperilled by another strike, and for a short time the Golden Horse Shoe and the Ivanhoe had to suspend operations. The trouble arises out of a dispute between the Chamber of Mines and the Miners' Union with regard to the working of the 44 hour week recently settled in the Arbitration Court. The matter is to go before the Court again. The latest news is that the miners are resuming work pending the decision of the Court.

Great activity has characterized the market in the shares of the Broken Hill Proprietary, owing to large buying orders coming from Australia. No published information has fully accounted for the rise in the quotation, but plenty of rumours have been invented and circulated. In general terms, however, it may be said that the condition and prospects of the steel industry founded by this company are quite worthy of any booming they get.

The Junction company at Broken Hill has made an agreement with the Amalgamated Zinc (De Bavay's), whereby the latter will treat Junction ore at the rate of 1,500 tons per week. This is the first time that Amalgamated Zinc has treated ore, its activities having been devoted hitherto to the concentration of zinc tailing. A new plant is to be erected at the Amalgamated's expense, and as the company is co-partner in the ownership of Minerals Separation's Australian patents, it is presumed that a modern type of the latter's plant will be adopted. The output at the Junction will be raised by 50 per cent.

The Mount Cuthbert Company started a copper smelter of its own in March, 1917, after having previously sent its ores to the Mount Elliott smelter. Since the reconstruction of the company in 1916, a large amount of development has been done. The principal properties are the Cuthbert, Kalkadoon, Mighty Atom, Warwick Castle, Orphan, Surprise, and Excelsior. The total ore reserves are estimated at 149,000 tons averaging 6½% copper. The blast-furnace has a capacity of 200 tons per day, and there are two converter stands. The properties are about 70 miles north-west of Cloncurry, and are in the same neighbourhood as the Dobbyn group belonging to the Mount Elliott. The railway connecting Cloncurry with Mount Cuthbert is to be eventually extended another 60 miles to Mount Oxide.

With reference to our mention in an Editorial last month of South Australian coal resources, we are informed that the Department of Mines has reopened the Leigh Creek brown coal deposits, and is taking out 500 tons for experimental purposes. This deposit is about 350 miles north of Adelaide, and is situated between the Flinders Range and Lake Torrens. The coal is of Jurassic age, and is friable on exposure to the atmosphere. The Mines Department is also conducting boring operations at Bower, about 80 miles north-east of Adelaide, where brown coal was found a few years ago.

A company called the Gurrumbah Tin Mines Ltd. has been formed in Sydney to acquire a group of lode-tin properties in the Herberton district of North Queensland, and also to purchase the Gurrumbah custom mill. The deposit consists of a mass of low-grade greisen, assays of which vary from 6 to 100 lb. tin oxide per ton, and the ore in sight is estimated at 230,000 tons.

New Zealand. — The titaniferous iron sands on the Taranaki coast are being smelted experimentally by the New Zealand Iron Ore Smelting Co. at Moturoa, and specimens of the iron produced have been sent to various foundries for testing. An extensive series of tests was conducted by Robertson & Co., of Wellington, and the results are reported to be encouraging.

The New Zealand Government is stimulating the production of quicksilver by renewing an old offer of a bonus of 4d. per lb. on the first 100,000 lb. produced. Cinnabar is known to exist at several places, and recently some mining was done by the Whangarei Cinnabar Mining Co. in the Puhipuhi hills, in Auckland province.

Cornwall.—We refer in our editorial columns to the ruling of the taxing authorities as to the incidence of the excess profits tax on Cornish lode mining, and to the terms made with East Pool in connection with the increased output of tin.

Tincroft Mines has been helped in a substantial way lately by the high price of arsenic, £130 per ton, or more than ten times the price of pre-war days. More arsenical ore has been treated recently, so that a bigger profit was made during the last half of 1917 than ever before, in spite of the fact that the yield of tin concentrate was only 17 lb. per ton.

Canada.—Labour conditions in the various mining districts of Northern Ontario are improving and the outlook is favourable for an active season. At the Dome Mines, at Porcupine, where operations were for some time suspended, work underground has been resumed, and the shaft is being sunk to the 1,500 ft. level. The mill will be started as soon as enough high-grade ore can be taken from the lower levels to make milling profitable. The annual statement of the Hollinger Consolidated for 1917 shows that the company has greatly strengthened its financial position since the suspension of dividend payments. The deficit of $269,500 has been wiped out, and a surplus of \$712,724 accumulated, while \$673,237 was expended on plant and \$131,224 on development. Payments of dividends amounted to \$738,000, as against \$3,126,000 in 1916. The total income was \$4,271,260, with a gross operating profit of \$2,009,549, and a net profit, after deducting depreciation, taxes, and donations, of \$1,720,134. The ore reserves showed an increase in total gold content from \$34,185,535 to \$40,231,435. This increase has come entirely from above the 800 ft. level, and the ground below is unexplored territory of great speculative value. The average grade of the ore reserves is estimated at \$8·95 per ton.

The British America Nickel Corporation has abandoned its project of erecting a nickel refinery in the Sudbury district, where its mine is situated, owing to the impossibility of securing electric power on the French River at a reasonable cost. The company is now looking for a site near Ottawa.

United States.—The latest information relating to the progress in the extraction of potash salts at Searles Lake, California, by the American Trona Corporation was given at the meeting of the South African Gold Trust last month. The output of mixed salts during 1917 was 13,558 tons, averaging 65% potassium chloride, estimated as being worth \$1,771,171, and 344 tons, averaging 98% potassium chloride, estimated as being worth \$145,868. The profit for the year, after allowing for depreciation, is estimated at \$960,000. It is expected that the present unit will be working at full capacity, 90 tons of mixed salts per day, within a short time. The erection of the second unit of similar capacity is delayed by the congestion of the railway service, and it is difficult to obtain priority for the delivery of the machinery. Two other smaller units having a combined capacity of 90 tons are also awaiting the machinery. The refinery at San Pedro, the port of Los Angeles, has started the extraction of borax from the mixed salts.

The results obtained by the Arizona Copper Co. during the financial year ended September 30 last were adversely affected by the strike, which lasted from the beginning of July to the end of October. The output of copper was 21·241 short tons, and the net profit was £876,760. After the payment of debenture and preference interest, £137,804 was placed to the fund for debenture redemption, £305,000 was placed to reserve, and £303,979 was distributed as dividend on the ordinary shares, being at the rate of 80% free of tax.

Mexico.—In his speech to shareholders of the Exploration Company, Mr. R. T. Bayliss had much to say relating to conditions in Mexico. While Mexico City and the southern parts of the country are now quiet, the northern states are still the scene of conflict between the Federal Government and the supporters of Villa. The Government appears to be doing its best to restore the country after the ravages of the past five years, but funds to do so effectively cannot come from within, and will not be available from outside sources until the close of the European war. As regards the mines controlled by the Exploration Company, the El Oro, 60 miles from Mexico City, has been in operation continuously since it resumed work eighteen months ago consequent on a threat of confiscation if it was allowed to remain idle. The mine is hard hit by the continuous demands for increased wages. The Santa Rosa gold-silver mine in the State of Zacatecas and the Buena Tierra silver-lead mine in Chihuahua have both been closed down for some time, and there is no expectation of a resumption at present.

Russia. — The position of the Russian mines under English and French control, following the collapse of the so-called Government and its submission to all the German demands, has become critical. The mineral resources of South Russia and the Caucasus are now at the free disposal of Germany. The influence of this conquest will be appreciated when the immense deposits of high-grade iron ore and coal in South Russia and of manganese and copper in the Caucasus are remembered. The Siberian position is not yet clear, and the ability of Japan and the Allies to prevent German influence spreading to the Pacific coast cannot be gauged. The Japanese appear to be the only nation capable of undertaking the barrage, but it is doubtful whether they will take active steps on the mainland unless they are allowed to protect permanently the whole of the territory east of Lake Baikal, and also Manchuria and part of northern China. The necessity for the protection of China is to some extent overlooked by the public, though the danger is reflected by movements on the Stock Exchange. It is well known that after the Russo-Japanese war the Russians, under German military advice, evolved a plan of penetrating through the Altai into Mongolia and thence by Urga to Pekin, thus to reach the Pacific by an alternative route instead of that by Port Arthur. The Pacific ports in Siberia, Vladivostok, Nikolaievsk, and Ayan, are not such as would be desired by Germany, for they are ice-bound in winter.

MINING IRON ORE IN THE MIDLANDS

By W. BARNES.

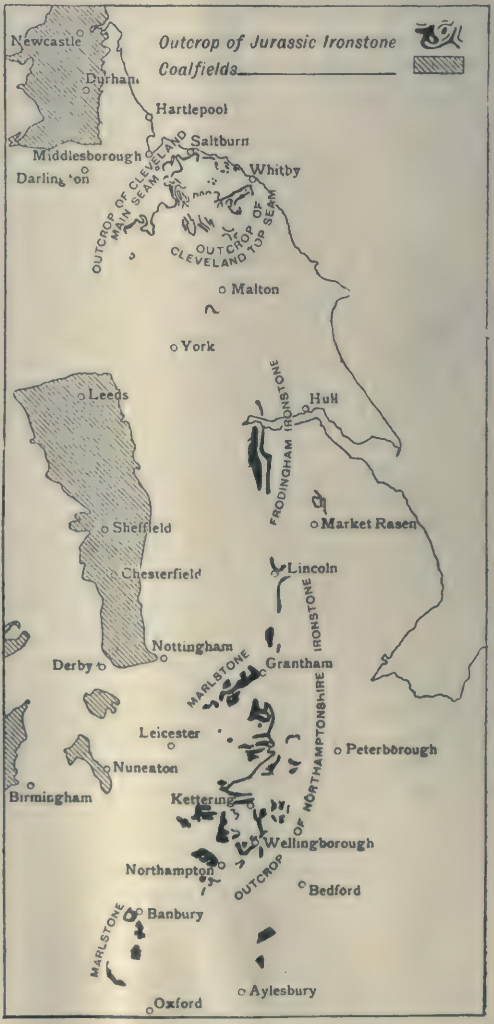
The Oolite and Lias iron ores in the Midland Counties are soft and comparatively near the surface. They are mined by steam shovel and similar types of plant. The author gives particulars of the method of opening and mining, and of the machines employed.

SEVERAL articles have recently appeared in the Magazine, concerning the iron ore deposits in this country and the endeavours that are being made to work them. More particular attention has been given to the Lias and Oolite deposits that occur near the surface in Lincolnshire, Northampton, Leicester, and other Midland counties. As these deposits are being exploited to an increased extent owing to war exigencies, it will be interesting to your readers to hear of the modern mechanical methods of mining applied here. These methods are rapidly taking the place of the hand labour hitherto used. By "near the surface" I mean depths varying from 3 ft. to 40 ft., and the methods and machinery illustrated and described here refer particularly to these depths. A large number of machines are being used in the Frodingham district of North Lincolnshire; also through Lincolnshire and on into Leicestershire, Northamptonshire, and Warwickshire.

The machines may be divided into two groups, the first being intended for removing the cover, or overburden, and the second that in use for getting the ore. In all cases the sizes of the machines in use depend upon: (1), the strength of the material which requires to be excavated, and (2), the output or quantity which has to be dealt with.

The method of working, irrespective of the size of the machines used, is as follows. A gullet is first driven through the cover to expose the ore, after which another gullet is driven through the ore itself, both of which operations may be and are largely carried out by machinery. The workings are then continued by a series of side cuts, the cover being removed from successive widths of iron ore and dumped on to the ground from which the ore has been removed. In most quarries the cover can be subdivided into subsoil and surface soil, both of which have to be kept separate and replaced in their correct relative positions upon the ground from which the ore has been removed, so that it can be cultivated again. Indeed so carefully and quickly is this carried out that crops have been grown again on the soil within a few months of its being disturbed. A typical section (see Fig. 1) through a quarry will make clear what is meant by the foregoing and subsequent explanations. The illustration with the notes and references at the foot are self-explanatory, so that little more need be said to make the *modus operandi* clear. The main thing to be noted and borne in mind is that the ironstone upon the dump, shown on the right-hand side, has been removed and the ground restored for purposes of cultivation.

What is, therefore, required in the way of



MAP OF THE MIDLAND IRON ORE DISTRICT.

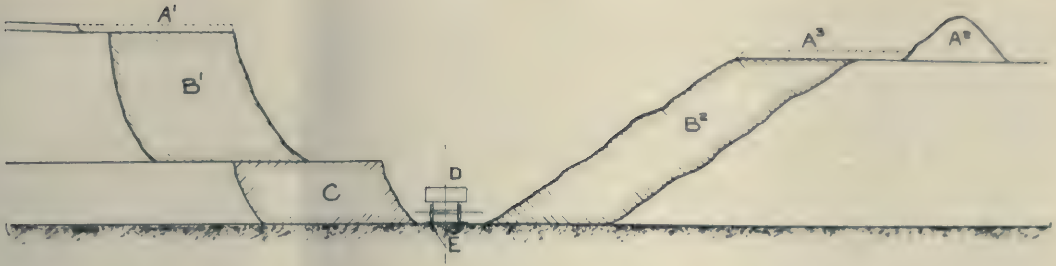


FIG. 1—SECTION SHOWING THE METHOD OF WORKING THE IRON ORE BEDS.

A^1 the top soil removed to a depth of from 6 to 12 in. and wheeled or otherwise transported to A^2; A^3 the top soil A^1 and A^2 spread and levelled on to the dump: B^1 a width of cover removed and dumped into B^2; C iron ore which, when it has been uncovered, is excavated and loaded into the wagons D running upon a through track E.

machinery is, first, an excavator to dig the cover; second, some means of transporting and dumping it on to the ground from which the ironstone has been taken; and third, another excavator to dig the stone after the cover has been removed. The machines mentioned under items one and two are frequently combined in the form of one machine, namely, a combined excavator and transporter, or a single machine having sufficient reach or radius not only to dig the cover but to discharge it on to the dump side. These will, however, be illustrated and described later. I will describe first the methods of working and then give the essential mechanical details of the machinery employed.

The illustration Fig. 2 shows a complete plant at work. The upper machine in the right-hand corner is excavating the cover, and dumping it into a wagon or skip running upon the inclined track of the large bridge-like structure known as a transporter. The lower excavator shown in the foreground is excavating the ironstone, from which the cover has been removed, and loading it into the train of wagons running alongside the machine, as shown in the left-hand corner. The wagons are arranged either upon an incline so that one wagon at a time can be lowered to the machine, loaded, and then released to make room for another, or, a locomotive is coupled to the train of wagons which are then shunted down past the stone-digger and filled. Both excavators are of the crane navvy type, which means that, like a locomotive crane, they are capable of being revolved through a complete circle. This is a most desirable, and indeed necessary, feature for ironstone quarrying, as it enables the machines to work backward and forward the full length of the face. Thus when the machines reach the end of the cut or working face the roads are slewed nearer the face, and the machines cut back again in the reverse direction, the ironstone digger being travelled under the lower and short cantilever arm of the transporter, so as to follow the cover machine and transporter upon the next cut down.

The following movements comprise a complete cycle of operations of the stripping plant, all of which can be performed in the total time of half a minute. The driver lowers the bucket to the bottom of the cut or working face until the bucket teeth rest upon the ground with the bucket arm hanging approximately vertical from the jib. He then starts the engines and throws in the clutch connected with the hoisting drum. The bucket is dragged forward and upward into the material to be excavated so that the bucket is filled just as the end of the cut, that is, the top of the cover or working face, is reached. He then racks the bucket in to bring the teeth clear of the working face, throws out the hoisting clutch to free the drum, and holds the bucket up by means of a brake, under the control of a foot pedal. The bucket is then swung or slewed round either by means of friction clutches operated by the main engines, or by a separate set of slewing engines (depending upon the particular design), until the bucket is immediately over the skip of the transporter. He then lowers the bucket by means of the footbrake until the bucket door, when it is opened, will just clear the sides of the skip, and pulls the cord which withdraws the catch holding the bucket door in place, thus transferring the excavated material from the navvy bucket to the transporter skip. The slewing gear is then set in motion again, but in the reverse direction, until the bucket is immediately over the next cut to be taken, and the cycle of operations is repeated.

Immediately the excavated material is dumped into the skip the driver of the transporter throws in the clutch of the winding engine, which is under his control, and the skip is hauled rapidly up the inclined track of the transporter until the desired point of discharge is reached, upon which a mechanical arrangement fitted to the track and the skip engage each other, the catch holding up the skip door is withdrawn, and the material is dumped on to the spoil bank. The transporter driver then throws out the hoisting clutch, and the skip runs down the inclined track under the control of a footbrake acting upon the otherwise freely revolving drum, until it comes to rest at the bottom of the track, to await the next load of material from the navvy which is just completing the cycle of operations that has been in progress simultaneously with those just described upon the transporter.

The operations described above are repeated until the excavator has cut away all the material within reach from the front, and as much from the side as is necessary for the width of cut that is being taken. During this time the men working around the machine have been cleaning up the front and preparing the bottom in readiness for another section of track consisting of timbers and rails, which are then transferred from the back of the machine to the front. The driver then puts in his travelling clutch and the machine is advanced about 5 ft. on to the newly laid track at the front. Wedges or chocks are then put behind the wheels to prevent the machine being pushed back when taking its cut and the machine is again ready for work. During these operations similar movements have been taking place with the transporter. Jack screws are fitted to the lower end of the track, and these have been released from the timbers resting upon the ironstone, the timbers moved on the distance it is required to move forward, the machine travelled ahead upon the fresh section of track previously laid, and the jack screws adjusted to the timbers again. The whole series of operations to both machines should be completed, and the machine ready for work again, in from five to ten minutes.

The ironstone digger in the bottom has also been busily engaged excavating and loading into wagons the ironstone laid bare by the stripping plant. The movements of this machine are exactly similar to those upon the navvy in use for stripping, so no more need be said about it.

The main details of the actual construction of the machines will now be described. The cover navvy will be dealt with first. The various details comprising the machine are fitted and assembled on two bedplates or framings. The lower framing carries the travelling wheels and gearing on the underside, and a large circular path or ring on the top, upon which the upper bedplate or framing revolves. Two sets of travelling wheels are fitted, one of 4 ft. 8½ in. gauge and the other of 9 ft. 6 in. gauge. The inner or standard gauge wheels have single flanges and are useful when the machine has to be travelled for any appreciable distance upon the standard 4 ft. 8½ in. gauge. The outer or broad gauge set have double flanges and are used to give stability to the machine when in use as an excavator. The centres of the travelling wheels are approximately the same as the broad gauge, namely, 9 ft. 6 in.; thus the machine stands and works upon what can be regarded as four corners of a square with sides 9 ft. 6 in. long, so that the stability of the machine is the same no matter in which direction it is excavating, a very useful feature. The power required for travelling is transmitted from the main engines upon the upper framing, through bevel gearing at the top and bottom of the centre post, about which the upper structure revolves, and thence by heavy plate link chains to sprocket wheels fitted to both axles. The machine can be travelled either backward or forward by means of the reversing gear with which the main engines are fitted. The engines, boiler, and all the gearing, excepting the travelling gear just described, are fitted upon the upper bedplate together with the excavating gear comprising the jib, bucket arm, and bucket.

The boiler is usually of the vertical cross-tube type, which gives the most satisfactory results where the feed water is of poor quality. The feed-water supply is carried in a large tank bolted to the rear of the upper bedplate, the boiler being carried by and bolted to it. The tank holds 800 gallons, which is more than sufficient for half-a-day's supply, and it can be filled either through a filling hole in the top of the tank, or through the centre travelling shaft of the machine, in which there is a hole for this purpose. The purpose of filling the tank through the centre of the machine is to enable the tank to be filled while the machine is working. The feed water is supplied to the boiler by a feed pump which forces the water through a tubular water heater, heated from the steam exhaust, before being finally fed into the boiler.

The main engines for hoisting or digging are of the horizontal type, bolted to heavy side frames carrying the main hoisting drum and spur wheel. The hoisting gear is driven through an outside band friction clutch, easily and quickly operated by means of a steam cylinder under the control of the driver. The hoisting wheel is keyed to the drum shaft, the drum being loose upon it and free to revolve

FIG. 2—The upper machine at the right-hand corner is excavating the cover; the material is sent by the transporter across to the other side of the cutting; the lower machine at the right-hand side is excavating the iron ore and leading it into the wagons.

when the friction clutch is off. The band of the friction clutch is fitted to the spur wheel, and coils and grips upon a clutch race fitted at one end of the drum. A brake race similar in design to the clutch race is fitted to the opposite end of the drum. A brake of similar construction to the clutch enables the driver to regulate the drum when it is running free to lower the bucket. The drum is fitted with spiral grooves of a size suitable for the wire rope used for hoisting. The slewing motion is either driven from friction clutches operated by the main engines, or, as in some designs, by a separate and smaller set of engines. In both cases spur gearing transmits the motion through the bedplate to a pinion gearing into the large gear ring resting upon, or bolted to, the upper framing. The underside of the bedplate is fitted with large cast steel anti-friction rollers which revolve upon the large gear ring when the upper structure is slewed or revolved.

The excavating gear is fitted to the front of the upper bedplate, at the opposite end to the bedplate and water tank. The jib is fitted with engines and gearing for altering the working radius of the bucket, by means of which the thickness of cut taken by the bucket teeth can be regulated as well as the radius for discharging, etc. The engines consist of a set of small self-contained double cylinder engines controlled and reversed by a single lever. A pinion on the engine crankshaft gears into a spur wheel upon the centre of the racking shaft. The racking shaft runs in bearings bolted to the jib, and, in addition to the spur wheel mentioned, carries two pinions gearing into racks bolted to the underside of the bucket arm. The racks are of such a length that a stroke of 12 ft. 6 in. can be given to the bucket arms. The bucket has a capacity of $2\frac{3}{4}$ cubic yards, and carries four teeth bolted to a heavy mild steel lip plate. The shanks of the bucket teeth run practically the full length of the bucket and are fitted with renewable points of manganese steel, the shape depending upon the material to be excavated.

The net weight of the machine is approximately 55 tons, and the gross working weight including coal and water about 60 tons.

The transporter consists of a framing carrying the travelling gear, a tower to support the track, and an engine and boiler for supplying the necessary power for hauling the loading skip up the track, and for travelling the machine. The engines are of the usual winding engine type, with double cylinders bolted to side frames supporting the drum. A pinion upon the engine crankshaft gears into the hoisting spur wheel. The latter is keyed to the shaft, and is fitted with a double cone friction clutch which can be engaged or disengaged with the drum as required. The drum is fitted with brass bushes, and is free to revolve upon the shaft under the control of a band brake. The travelling gear is driven from a set of reversing bevel pinions and wheels fitted to the crankshaft, through the framing to bevel gearing on the underside and thence to both axles. Two cast steel travelling wheels are fitted to each axle at approximately the four corners of the framing. They are made with double flanges to give ample room for the rail heads. The four legs of the tower are stepped into and upon the framing immediately above the travelling wheels. The track passes through the tower and is supported from its upper four corners by tie rods or slings. It consists of two mild steel channels with rectangular section rails riveted on to the upper flange. The upper end is fitted with pulleys around which pass the wire rope for hauling the skip up the track. The lower end is fitted with stop blocks, and a ballast box carrying the necessary counterbalance to counteract the effect of the fully loaded skip at the extreme end of the track. Jacks are fitted to the bottom end of the track, which, when screwed down upon the ironstone, take the shock of dumping the material from the navvy bucket to the transporter skip.

The skip or wagon is constructed of mild steel plates, and is of approximately 25% greater capacity than the navvy bucket, and is 6 ft. square at the top to give plenty of latitude, thus avoiding spilling the material when it is being dumped from the navvy bucket. The skip is fitted with a bottom door supported by hinges from the sides. A latch is hooked under the front edge of the door which can be mechanically tripped to release the door and discharge the contents of the skip. The tripping is accomplished by the release of a suspended hammer; this hammer, falling upon the latch lever, causes it to release its hold upon the door. The weight of material upon the door causes it to open and the contents are discharged. The lowering of the skip down the track restores both door and tripping hammer to their original positions in readiness for the next cycle of operations. The gear for releasing the tripping hammer runs upon slides on the track channels, to enable it to be moved anywhere on the track by means of a hand operated winch under the control of the driver. The position of the tripping jack on the slide determines the point at which the load is dumped.

The construction of the ironstone digger is generally similar to the cover navvy described, but it is strengthened to meet the increased stresses due to dealing with the heavier and more compact material, thus a heavier lip plate and teeth are fitted to the bucket. The jib, bucket arms, "A" framing, and jib ties are all somewhat stronger.

Another useful plant is shown in Fig. 3. It comprises a navvy fitted with a long jib and bucket arm to enable the excavated cover to be discharged directly on to the dump, and an ironstone digger similar to the one described in connection with Fig. 2. The construction of the cover machine is almost identical with the one described in conjunction with Fig. 2, but instead of a jib 30 ft. long, giving a maximum dumping distance of about 32 ft., it is about 60 ft. long for a discharging radius of 60 ft. or less. The cutting pressure is reduced in proportion to the working radius of the machine, and the bucket has a correspondingly smaller capacity. The jib, it will be noticed, is of the open lattice type of construction. The bucket arms are of great length and fitted with racks to give an extremely long stroke to obtain the necessary dumping radius. It weighs approximately the same as the machine shown in Fig. 2, but owing to the necessarily smaller bucket and the longer jib, a much smaller output is obtainable and heavy materials cannot be dealt with owing to the decreased cutting pressure which has to be used. Larger machines of this type weighing 200 tons are, however, in use, which compare favourably both as regards the quantity and density of material which can be dealt with.

Another useful cover machine combining a navvy and transporter is shown in Fig. 4. It weighs approximately 90 tons, and is capable of dealing with 700 cubic yards of ordinary material per day, with two men upon the machine and four around it. It is fitted with four sets of engines. The largest set controls the hoisting or digging motion, another hauls the transporter skip up the track and travels the machine as required, the slewing gear is connected up to a third set, while the fourth set is mounted upon the jib for controlling the working radius of the bucket. One boiler is fitted, the firing of which is done by the driver controlling the skip-haulage engines. All the motions of digging are under the operation of a driver situated high up in the tower of the machine, from which position a good view of the working face is obtained. The actual operations of digging are similar to those with the machines described above, but instead of the bucket being slewed out of the working face for discharging after the cut up the face is completed, the hoisting is continued until the bucket is pulled up into the jib and over an inclined chute leading to the skip at the lower end of the track. The door of the bucket is then automatically tripped, and the contents are discharged down the chute into the skip.

FIG. 3—In the distance is a machine for digging the cover and discharging it direct to the dump; in the foreground the machine is digging iron ore and discharging it into wagons.

FIG. 4—Another type of machine for dealing with the cover, consisting of a digger and transporter combined.

The skip is then hauled up the track and dumped in a similar manner to that with the transporter described in connection with Fig. 2. The machine stands upon the ironstone and travels alternately backward and forward the full length of the quarry face, taking the cover off in widths of about 12 ft., and dumping it over on to the ground from which the ironstone has been removed.

The construction of the machine is as follows. The framing is fitted with three sets of bogies which can be swivelled to travel the machine in any direction. The framing may be described as triangular in plan, two sets of bogies being fitted to the corners of the triangle nearest to the transporter, and one set at the apex immediately under the foot of the jib to give a three-point bearing. The travelling gear is connected with all eight wheels comprising the two main sets of bogies at the rear. The framing of the machine supports the tower, jib, track, engines, gearing, and boiler. The tower supports the jib and excavating gear at the front and the transporter at the rear. The jib is stepped into a turntable at the front of the machine and is held in position by ties carried from the jib head back to a swivelling head piece at the top of the tower. The engines for controlling the thickness of cut taken by the bucket are fitted to the jib. The chute for transferring the material from the excavator bucket to the transporter skip is carried by and riveted to the jib. The slewing gear fitted to the jib turntable is so arranged that the jib can be swung through rather more than half a circle by means of the slewing engines fitted upon the front portion of the framing. The hoisting engines are bolted to a platform in the tower itself, and consist of a set of double cylinder engines bolted to side framings supporting the drum and gearing. The drum is fitted with a steam-operated outside band clutch for hoisting, and a band brake for lowering the bucket when the clutch is thrown out of gear. The drum is fitted with a chain which passes under and over pulleys at the head of the tower, round a pulley at the jib head and thence to the bucket. The bucket is built up of plates riveted to a heavy steel bucket back casting, and carries the usual type of bucket teeth bolted to a renewable cutting edge or lip plate. The bucket arm is suspended from the jib and is fitted with racks by means of which the working radius can be altered as required. The transporter track passes through the tower, the lower end terminating at the slewing centre of the machine, the upper end projecting out over the dump and being supported by slings to the tower. The top flanges of the channels forming the track are fitted with rails, upon which run the skip, fitted with tripping gear similar to that already described. The skip can be arranged to dump at any desired point by means of a sliding tripping jack adjustable from a hand-operated winch under the control of the transporter driver. The skip is hauled up the track by means of a set of engines similar to those described upon the separate transporter, a friction clutch being fitted for hauling the skip up the track, and a brake for controlling the lowering. A full cycle of operations comprising taking a cut, discharging the excavated material down the chute, travelling the skip up the transporter, dumping the contents of the skip, and lowering the skip to the foot of the track again can be completed in 20 seconds. The machine is therefore exceedingly rapid in its various movements and is capable of a big output with but few men in attendance.

The foregoing describes the machines most generally in use. Variations occur in connection with these; for instance, the belt conveyor sometimes takes the place of the separate skip, while for easy cover, such as the sand and peat in the Frodingham district, machines combining an endless chain of buckets like a dredger, discharging on to an endless belt conveyor, are in use. Doubtless as the working conditions of the quarries alter, particularly as the cover gets deeper, as it eventually will do in many places, new machines will be introduced to meet the new conditions.

The Geographical Journal, the monthly organ of the Royal Geographical Society, has a particularly interesting issue for March. It contains General Smuts' paper on East Africa, which was read during the air raid of January 28. This paper contains details of the German propaganda relating to the establishment of a "Mittelafrika," which was to include all tropical Africa, from Sierra Leone, through the Gold Coast and Nigeria to the Congo State, Angola, Northern Rhodesia, Nyassaland, and part of British East Africa, in addition to the Cameroons and German East Africa. German colonial policy is dictated by the desire to obtain control of the commercial products and not the foundation of colonies for German population. The *Journal* also contains a paper on the southern part of German East Africa by Mr. Owen Letcher, an authority on the geology and geography of South Africa well known to our readers, and one on the future of Siberia by Colonel Harald Swayne.

MONUMENTS OF FOLLY.

By JOHN McCOMBIE.

The author calls attention once more to the necessity of applying sound business and technical methods to prospecting and development operations, and cites three instances of folly due either to ignorance or desire to deceive.

ALL mining work, even in the initial stages, should be treated as part of a well thought out scheme, and the avoidance of waste should become the first consideration. The embryo developments should be conducted in such a manner that the work performed can be turned to account when the property comes to be handled on a large scale. It is a very wise precaution to follow the ore from the surface downward, as far as water and other circumstances will permit, before undertaking the more expensive work of driving adit levels, or sinking shafts. "Make sure you are right and then go ahead" is a maxim that should always apply in gold mining, because money spent upon unwarranted extensive developments is a positive waste, and a reflection upon the judgment of every person connected with such outlay.

The uncertain distribution of payable ore shoots, as well as that of lode continuity, is very great in metalliferous mining, and hence the necessity for mine owners to feel their way before launching into heavy expenditure either for opening up a mine, or for the erection of milling machinery. It is generally conceded that fully fifty per cent of all expenditure in connection with gold mining is wasted, chiefly because the persons interested will not take a common-sense view of the industry, and deal with it accordingly. At every gold-mining centre throughout the world thousands of pounds sterling have been literally thrown away upon ventures where the outlook did not warrant the expenditure of so many shillings.

Scattered broadcast over our goldfields today are "Monuments" of the ignorance, incompetence, or recklessness of the persons who controlled such propositions. These "Monuments" take the shape of milling plants, shaft equipments, water races, together with mine developments, involving the outlay of large sums of money, and those who run may read the barren results everywhere. Some of these are the outcome of barefaced "swindles" successfully engineered from the very outset, while others can safely be attributed to the grasping greed of the mine owners. Their inordinate desire to accumulate filthy lucre speedily induced them to invest in gold mining, which they did not look upon as being a legitimate branch of industry, but, trusting to scrip market fluctuations to see them out on the right side of the ledger, they embarked their capital in all sorts of wild ventures.

By way of illustration: we will suppose that the Roaring Gimblet Mine has been located upon a lode system, and that the surface indications are favourable. The next form of procedure, in order to get a market value on the shares, is for the owners to ignore the want of development on the mine, and to devote all their available capital and energy to the erection of an ore-treatment plant. By the time the machinery is in complete working order there is no money in hand to exploit the mine, and, as the ore will not of its own accord roll out of the bowels of the earth into the mill hoppers, the whole concern comes to grief and liquidation follows. Briefly this is the history of a legion of mining failures, and unfortunately the same influences are in full operation to-day. I could name several mining propositions which are now being conducted upon lines that are simply scandalous, and all because the owners will not profit by other people's experience, or pay for expert advice. Hereafter I shall endeavour to describe in detail some of the most glaring mining blunders that have come under my notice during a residence of fifty years on various goldfields, and, if I can only induce the ordinary run of mining men to "look before they leap" I shall not have written in vain.

The statement attributed to Napoleon, that it takes three things to win battles, money, money, and more money, may be applied to gold mining, with equal aptitude. Without capital it is impossible to carry out any gold-mining enterprise to a successful issue, and then a great deal depends upon the allocation of the expenditure. It is scarcely possible to outline a solution that will meet every failure, and I am not going to try my hand at the game. I will, however, make an effort to show that a careful investigation at the outset would often tend to prevent a useless expenditure of money, and thereby lessen the number of mining mistakes.

MONUMENT NO. I.—The property about

which I am now going to write was owned by an English company, which subscribed a large sum of money for mining development, as well as for the construction of water races and milling machinery. The outlook in the mine was most promising, but all the expenditure on the surface was very badly controlled. The first bungle that came under my notice was in connection with the work of building No. 1 water race. Tenders were invited for its construction, and, regardless of the financial standing of the man, the lowest tender was accepted. It was nothing short of fatuous folly to imagine for one moment that the successful tenderer could carry out the work in accordance with the specifications, because his price was fully 25% below the estimated cost, and consequently he began to "scamp" the work soon after starting. Inferior timber was used for framing studs and lining boards, and the foundations of the flume were of the flimsiest possible description. Before one fourth of the work was accomplished the contractor's credit was stopped by the local business people, and this meant a through ticket for the bankruptcy court without any return. Realizing the seriousness of the situation the company gave the contractor seven days' notice of their intention to re-enter the contract, and to complete it at the contractor's expense. Unfortunately the notice did not allow for a Sunday which intervened, and therefore the whole of the proceedings were wanting in legality. Acting in accordance with his solicitor's instructions, the contractor sued the company for the full amount of the contract money, and the Court gave judgment for the claim as well as costs. Then the company was obliged to complete the water race by the employment of wages men, and, instead of the expenditure being 25% less than its true value, the actual outlay was fully 50% more than the engineer's original estimate.

Later on the work of constructing a second flume for water-conveying purposes, on a different stream, was carried out by the same company. This race, composed entirely of timber, was erected with a view to harnessing a water supply which took a serpentine course, and flowed through the centre of the property. When the levels were taken it could easily be seen that the fluming had to follow the sinuosities of all the gullies crossing its course. This had the effect of increasing its length fully half a mile, and adding proportionately to the cost. At the same time the possibilities for installing a cheaper water conveyor, either flume or pipe line, on the short side of the stream, were staring all hands straight in the face. Nevertheless the work was carried out on the long side, and when complete the waterway formed the letter "S" at quite a number of points along its line. By way of minimizing the outlay, which exceeded the estimate by a large sum, the foundations for the fluming were so badly arranged that the subsequent cost for maintenance proved to be a very serious item in the monthly expenditure. To-day this water race stands out in such bold relief as to prompt every visiting mining man to ask the question: "Why was it built on the wrong side of the stream?" and echo answers "Why?"

MONUMENT NO. II.—It is a common practice on many goldfields for individual gold-mining companies to construct expensive dams and water races long before the mine itself is sufficiently exploited to determine whether the extent and value of the ore deposit warrants the outlay. Such expenditure can be written off as a complete loss if the mine is not a payable one, and especially if there is no other local demand for water power. Whereas if a steam plant is installed, and the mine proves to be a failure, the boiler and engines can be removed, and the loss minimized to a considerable extent.

Without risk there seldom is any great gain, and a fair gold-mining prospect is always worth sufficient expenditure to test its value, but heavy outlay on surface plant should always be avoided until the mine is proved beyond the shadow of a doubt.

The company owning the property referred to was floated in London, and the bulk of the subscribed capital, amounting to about £50,000, was expended upon the erection of a 40 stamp mill as well as two distinct water races and an aerial tramline. The water races were known as the high and low level supplies, respectively, and both were constructed with a view to operating the milling machinery by water power. The first-mentioned race commenced at a point on a creek containing a fair quantity of water throughout the wet season, which usually lasts about three months, but for the remainder of the year the liquid element was a scarce commodity. The company's representatives arrived on the scene in the depth of winter when all the streams were running a "banker," but it is quite evident that they made no effort to ascertain the normal condition of the water supply throughout the various seasons, because they started right away with the construction of the flume. The work was completed about the middle of the summer season, when there was not more than enough water obtainable to cover the flooring boards of the flume, and the delivery at the mill end was valueless for power purposes. Therefore the money expended, amounting to hundreds of pounds, resulted in no advantage to the company, and the whole concern could be denominated a very bad investment.

The low level water race was a more pretentious undertaking, and its construction involved an outlay of several thousands of pounds sterling. Here the average water supply, when taken all the year round, was not sufficient in quantity to warrant the installation of an expensive water race. Nevertheless the work was carried out, and some of the blunders in connection therewith are among the worst of the kind that ever came under my notice. About halfway between the dam and the mill there is a deep and narrow gully crossing the line of the water race at nearly right angles to its general course, and running back toward the main range for a distance of about half a mile. Now, instead of bridging this gully with a syphon pipe about 200 ft. in length, the men controlling the work carried the race right up on one side, around the head, and down the other side of the gully, adding nearly one mile to its length, and, as the side line cuttings were fairly deep, the cost must have been a correspondingly heavy one.

Meantime developments in the mine revealed a lode thirty feet in thickness, and the ore was reported to contain gold and silver in quantities that were more than payable. Eventually the ore-treatment plant, water races, and all the tramline connections with the mine were completed in every respect, and, after a heavy downpour of rain, the water power available enabled the management to make a start, crushing with 20 stamps. Coincidently a strong demand set in for shares, which jumped immediately beyond par value, and a payable return from the first crushing was the only thing required to "boost" the market value up to a very high figure. Crushing operations were continued for some time, when a large tonnage of ore was dealt with, but the bullion returns did not liquidate the cost of breaking and transit, leaving that of treatment out of the question altogether.

The company was re-formed, more capital subscribed for further exploitation of the mine, but experts reported unfavourably upon the outlook, and the whole concern was closed down. The sale of the machinery did not realize a tithe of its original cost, and finally the mine was abandoned.

Summarizing this proposition: The ore exposed to view in the mine was not sufficient in quantity, or rich enough in quality, at any stage of its development, to guarantee heavy expenditure upon either water races or milling machinery, and a careful analysis of the prospect would have proved that at the very outset. If the money squandered on the surface had been employed to open up the mine the whole concern might be in profitable operation to-day, for it was closed down without having had a fair trial; and there are a good many experienced men, having a knowledge of the locality, who consider that it was worthy of a better fate.

MONUMENT NO. III.—To avoid mining mistakes in the future one must study, and, to a certain extent, be guided by the blunders of the past. In order to do this I am taken back to the New Zealand gold-mining boom, which commenced some time in the early part of the year 1895. Then prospecting operations were in progress upon a good many gold-mining ventures, and among these is the mine about which I am now going to write. Although this property was situated in a proved belt of auriferous country, all the lodes contained within the boundaries, so far as developments had gone, were small in size and low-grade in value. Before the boom had reached its most imbecile stage, the mine in question was controlled by a syndicate who bulled the shares up to a most ridiculous price, and reports were issued leading investors to believe that it only required a full fledged ore-treatment plant to place the concern in the front rank of bullion producers. Subsequent events, however, proved that there was not enough payable ore in sight throughout the whole of the workings to warrant the purchase of a prospecting outfit, much less an expensive crushing and cyanide plant. Nevertheless it was resolved to construct a 20 stamp mill, together with all the up-to-date appurtenances belonging thereto, and periodical calls were levied on the shareholders to provide the requisite funds. After a long period of delay the mill was completed at a cost of about £12,000, and the work of ore treatment was commenced with great enthusiasm.

To explain the ensuing procedure it is necessary to say that the "talent" operating the sharemarket had an army of "touts" in every mine and mill throughout the goldfields. Ostensibly these men were working for and paid daily wages by the various companies, but, in reality, they were in receipt of regular payments for supplying the "bulls" and "bears" with first-hand information, and, therefore, the shareholders were outpaced every time there was an upward or downward tendency in the market value of shares. Believing the mine to be worthless as a producer of payable ore, the "talent" sold thousands of shares for forward delivery within three months, at fairly high figures, and then they quietly awaited the results of the first crushing. This, they knew full well, from information supplied by the "touts," would kill the mine, and bring the value of the shares down to nothing.

The ore was free milling, and, after the first week's run with 20 stamps, there was no concealing the fact that the recovery would not yield an average bullion return equal to liquidating the cost of mining alone, and then the best of the ore was under treatment. To continue crushing subject to such conditions, with a view to cleaning up at the end of four weeks, meant playing right into the hands of the "bears," who would score heavily at the expense of the shareholders, and the money involved ranged up to five figures. The remedy, however, was applied one night when the mill had been running about fourteen days. Upon this occasion the engineer in charge of the plant heard a loud screeching noise, which appeared to come from the cam shaft, and he shut off the power in order to ascertain the cause. A close examination of the reduction works revealed the fact that emery powder had been poured lavishly on the revolving machinery. This had the effect of corrugating the shafting and cutting the bearings right down to the plummer blocks. A general suspension of operations ensued, and fully four months passed away before the requisite repairs were completed. In the meantime there was an upward tendency in the shares, and the "bears" having to face a firm market, had the utmost difficulty in delivering the goods. This involved some of them in such a heavy loss that they had to seek the protection of the bankruptcy court, and the general verdict was "served them right."

Eventually crushing operations were resumed, and all the ore broken out was dealt with for a bullion return, which did not produce sufficient money to pay for the mercury and cyanide used in its treatment. The mine was abandoned, and the sale of the machinery for a paltry figure came next in the order of things. To-day the scene is a most desolate one, but the mill foundations are still intact, and for many years to come they will serve as a "monument" of the reckless manner in which a large sum of money was frittered away when the outlook for the whole proposition did not warrant one penny of such expenditure.

Ducktown Sulphide Deposits.

The Ducktown district is situated at the south-eastern corner of Tennessee, and deposits of pyrite and pyrrhotite containing copper have been worked since 1850. In 1908 anti-fume agitation made it necessary to establish the manufacture of sulphuric acid as an accessory to copper-smelting. The two operating companies are the Tennessee Copper Co. and the Ducktown Sulphur, Copper, & Iron Co., the latter being an English organization. The chief mine of the Tennessee company is the Burra Burra, where the reserve amounts to 10,000,000 tons averaging 25 to 30% sulphur and less than 2% copper. The output of sulphuric acid is about 250,000 tons per year. The Ducktown company operates the Mary and East Tennessee mines, and produces 50,000 tons of acid per year. There are other sulphide deposits in the district composed mostly of pyrrhotite and containing under 1% of copper, that will prove valuable for sulphuric acid manufacture. These are the Isabella-Eureka and the School Property. The Isabella section of the Isabella-Eureka deposit belongs to the Ducktown company, the Eureka section to the Tennessee company, and the School Property to Mr. W. Y. Westervelt. At the Isabella 2,500,000 tons of ore has been blocked out, averaging 29% sulphur, with about 1% each of copper and zinc. At the Eureka about 2,000,000 tons has been blocked out, of much the same tenor. At the School Property, a campaign of diamond-drilling is in hand, and a large mass of mineral has already been proved, the assays of the cores indicating 42% sulphur, ½% copper, and 1½% zinc. The three properties are said to contain sufficient sulphide to supply 500 to 1,000 tons daily to sulphuric acid works for thirty years. The sulphides in the Ducktown district occur in lenticular masses more or less connected, varying from 1,000 to 5,000 ft. in length and from a few feet to 100 ft. in width. Some of the masses have been explored to a depth of 1,000 ft., and their limits have not so far been reached. The pyrite deposits extend beyond the State of Tennessee into Georgia. Across the border, about two miles south-west of the School Property deposit, is the No. 20 mine, where 1,000,000 tons of sulphide averages 20% sulphur and 2% copper.

THE EVOLUTION OF ORE DEPOSITS
FROM
IGNEOUS MAGMAS

By W. H. GOODCHILD, A.R.S.M., M.Inst.M.M., F.G.S.

(Continued from the February issue, page 82).

In this series of articles the Author discusses the principles governing the segregation of ore deposits from rock magmas, introducing several new factors in addition to those already put forward by geologists. He shows how the specific action of certain gases and mineralizers, notably hydrogen and its compounds, together with changes in volume accompanying the later chemical adjustments, explain many obscure problems in the formation of ore deposits.

The Formation of Pyrrhotite.

The next step is the formation of pyrrhotite. In order to understand this, perhaps one of the most important, and in some respects peculiar, reactions in the whole scheme of ore deposit construction, it is essential to clearly grasp the significance of the discontinuity or hiatus in the series of solid solutions of sulphur in ferrous sulphide. At one end of the series are the pyrrhotites, the dilute, and to some extent dissociated,* solutions of sulphur in FeS. These are represented by the general formula $Fe_n S_{n+1}$. Then comes the break, the solutions of S in FeS of intermediate concentration being unrepresented in the solid state on account of their instability at low temperatures. At the other end are two solid solutions of the "intermetallic compound" type, namely, pyrite and marcasite, which are indentical in composition but differ constitutionally for they are neither isomorphous nor have they the same density. This discontinuous series is in all probability the low temperature facies generated by the breakdown of a continuous series of solutions, namely, the solutions of H_2S in FeS, which are stable only at fairly high temperatures and pressures and can probably have any concentration of H_2S from zero to an equimolecular ratio of H_2S to FeS, comparable with a monohydrate in the case of the corresponding ferrous oxide. It has been shown by the author that the properties of marcasite are consistent with the view that it is the solid solution of polymerized monoclinic sulphur in FeS, pyrite being the corresponding solution of orthorhombic sulphur. Orthorhombic and monoclinic in this connection refer only to the crystallographic symmetry of sulphur in the free and uncompressed state. Now the transition point of monoclinic to orthorhombic sulphur in the free state is about 96°C. under atmospheric pressure, but the corresponding transition point of marcasite to pyrite is about 520°C. But increase of pressure greatly raises the transition temperature, as is shown by experimental investigations, while the pressures used experimentally have been small in comparison with the intrinsic pressures of liquids as calculated from surface-tension measurements. The combined effect of increased polymerization and solution in FeS, or to put it in another way, solution of sulphur in an associating solvent, is to greatly raise the transition point of the metastable or monoclinic variety.

In reviewing the chemistry of elemental sulphur the author drew particular attention to its two-phase character in the gaseous state at moderate temperatures, also to its extraordinary melting phenomena and to the fact that the latter have been demonstrated experimentally to be due to a polyphase character. These facts, coupled with the transition-point evidence and the existence of the two dimorphous forms pyrite and marcasite as well as the nature of the pyrrhotites, taken together, indicate with singular force that the polyphasic character of sulphur probably persists when it is dissolved or co-melted in FeS under the pressures requisite to prevent volatilization of the S. The saturated solutions, pyrite and marcasite, thus represent liquid compressed sulphur dissolved in FeS, and their comparative stabilities and special properties are considered to be due to *saturation* with compressed or highly associated sulphur in contradistinction to the solidified but unsaturated partly dissociated systems represented in the dilute solid solutions, the pyrrhotites. Now owing to the somewhat basic character of the Sudbury magma and the changing composition of the matte during the separating process it follows that the FeS would not be saturated with sulphur or H_2S, but would be a more or less strong solution of S or H_2S in FeS. It follows then from the

*The density of the dissolved S in pyrrhotite was stated in the May issue as approximately 6, or the same as in pyrite. This is an error in computation that has become apparent in checking calculations in the course of developing the subject matter of the present article.

ordinary laws of solutions that the effect of dilution or increasing the ratio of FeS to S is equivalent to gasifying the dissolved, polymerized or compressed sulphur, thus facilitating and accentuating the interaction between the different sulphur phases. The plight of the system is therefore like that of the city divided against itself while the enemy, in the shape of plenty of additional iron, is at the gates, that is to say, in the neighbouring basic silicates. In the case of concentrated but unsaturated solutions of S in FeS, then, the inevitable result of this interaction of the phases of sulphur dissolved in molten FeS while it is surrounded by basic silicates, is to cause part of the sulphur to attack the silicates with the formation of more FeS at their expense until the FeS solution becomes so impoverished in dissolved sulphur that it can exist in equilibrium with the surrounding silicates. This breakdown of the stronger solutions of S in FeS to form pyrrhotite as cooling proceeds is analogous to ordinary pneumatolytic decomposition or the evolution of occluded gases by cooling.

But the solution of S in FeS is due to the breakdown of solutions of H_2S in FeS, the H_2S being highly condensed. When this breakdown occurs in contact with basic ferruginous silicates there is an enormous increase in volume not only of the sulphides but a net increase in volume of the mixed mass of sulphides and silicates due to the expansion of sulphur, in conjunction with the oxidation of hydrogen to form water at the expense of oxides of iron. The approximate magnitude of these expansions can be calculated for the upper limiting term of the sulphur solutions, pyrite, as follows, and it gives a useful and practical idea of the great increases in volume that occur as an integral part of the matte consolidation process.

	FeS_2	Fe	2FeS	(1)
Formula weights............	120	56	176	(2)
Specific gravities............	5	7·9	4·6	(3)
Specific volumes (solid) (2) ÷ (3)	24	7·2	38	(4)

$$\underbrace{24 \quad 7{\cdot}2}_{31{\cdot}2} \text{ expands to } 38$$

38 − 31·2 = 6·8 . 6·8 ÷ 31·2 × 100 = over 20% net expansion.

The increase in volume of the sulphides, calculated approximately to pyrrhotite, neglecting dissolved sulphur, is 38 − 24 = 14; 14 ÷ 24 × 100 is say 58% approximately.

Similarly it can be calculated that the oxidation of the hydrogen to water in the free state, by reduction of Fe_2O_3 to FeO in the silicates, produces an expansion in the neighbourhood of 1,000%. On the basis of 9% FeO in the surrounding rock, some 4 tons or so of silicates, or say 40 cu. ft., become involved in the conversion of a ton of the sulphurized matte into pyrrhotite. Taking pyrrhotite as 7 cu. ft. to the short ton, about 2·5 cu. ft., or say about a third of the total volume, would represent replaced silicates arising from the conversion process. The term "conversion" is used in this connection because the process, in its more extended developments in association with highly acid magmas and the evolution of ore deposits therefrom, becomes more nearly akin to bessemerization.

These and the following figures are, of course, only rough approximations since they are based on the upper limiting value of dissolved sulphur concentration which would not be reached in the case of a semi-basic magma such as the Sudbury, consequently the actual silicate replacement and disruption observed there would be less, but this limiting value probably is reached in the case of such an acid magma as granite, the commonest of all magmas, when the encasing rock is a basic one. They make manifest two important points in connection with silicate disruption and replacement, namely, that although the amount of pyrrhotite and other sulphides that occur replacing silicates may appear under the microscope as a not inconsiderable proportion of the total volume of sulphides, this replacement is but a small proportion of the total volume of silicates that tend to become involved in the silicate disruption necessary to supply the additional iron. The importance and significance of this second point become more apparent when dealing with the conversion of the more highly gassed mattes accumulated at the upper margins of acid magmas, since it appears to be one of the causes that contribute to the expulsion of the matte to long distances into the country rock away from the region of its preliminary concentration, giving rise to mineral veins and various kinds of replacement deposits, the prototype of which is represented in the Sudbury offsets.

The Hydrothermal Effects of Matte Conversion and the Formation of Acid Extracts.

About 3 cu. ft. of H_2O are generated by oxidation of hydrogen at the expense of the oxides of iron in the silicates per ton of pyrrhotite and this is obtained by attacking some 40 cu. ft. of silicates. The average analysis of the basic norite is taken for this computation, but of course it is the ferro-magnesian minerals that are involved in the generation of the water. As this water is liable to react with the felspathic and other constituents when formed, the whole rock in the neighbourhood of the ore-bodies tends to become involved and hydrothermally altered to a greater or less extent.

This additional water, be it noted, is not very great in amount, but its mode of introduction, namely, as nascent H_2O, generated by expanding nascent hydrogen at a fairly high temperature and diffusing it intramolecularly into the body of the ferro-magnesian silicates, is as drastic and irresistible method of decomposing them as it is possible to conceive. It affords another instance of the remarkable efficiency and simple directness of the physico-chemical processes operative in the evolution of ore deposits from igneous magmas. This water, so to speak, reinforces the normal water of constitution of the previously solidified silicates so that the two together produce that local but nevertheless rather widespread though mild form of hydrothermal alteration that has given rise to the idea that the sulphides at Sudbury have been introduced by thermal waters, whereas it is worth emphasizing that it is the sulphides themselves that have introduced the hydrogen for making the water and are consequently the prime cause of the hydrothermal alteration. Thus we are once again brought face to face with the misleading ineffectiveness not only of the microscopic method by itself but also of field observation unless the data so obtained are supplemented and correlated by the application of physico-chemical methods to the study of the phenomena.

The general effect of abstracting iron from the silicates and converting it into pyrrhotite or other sulphide minerals, can be gathered by recalculating the basic average, as given in column 4 of the analytical table on page 23 of the January issue, with the iron taken out and the oxygen of the iron oxides calculated to H_2O.

The two sets of figures are given below for comparison; the figures being percentages and each row adding up to 100.

SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	P_2O_5
52·8	1·1	18·5	0·28	9·14	4·9	7·6	2·6	1·3	1·3	0·1
57·1	1·2	20·0	—	—	5·3	8·2	2·8	1·4	3·8	0·1

The comparison shows clearly how it comes about that the formation of the larger ore-bodies at Sudbury is apt to be accompanied with the collateral production of quantities of acid material, mainly quartz and felspar. It also illustrates the hydrothermal effect. These so called "acid extracts" and their mode of formation, which had given rise to much discussion by Sudbury geologists, are of world-wide interest and fundamental importance in the general theory of the evolution of ore deposits from igneous magmas. Once more the Sudbury deposits furnish a prototype, of gangue formation in this case, which gives us the key to the silicate alteration and gangue composition of a great variety of ore deposits derived from igneous magmas. Commencing with an accumulation of gassed matte at the margin of, say a granite batholith, propel this seriatim along some line of weakness in the encasing rock of different basicity, though a plane of weakness is not absolutely necessary, by the iron, sulphur, hydrogen combination physico-chemical mechanism, in conjunction with a powerful pressure mechanism to be discussed later, and it is easy to show, by taking into consideration the consolidation laws of both silicates and sulphides, as developed by petrography and metallography, coupled with the specific properties of the various sulphides that may be present in the gassed matte, how a great variety of mineral veins and replacement deposits may be developed. The deposits may also tend to show zoning of one kind and another, and in the limit a barren quartz vein may even conceivably be the outcrop showing little or no indication of the metallic sulphides to which with their load of gases it owed its origin. The separation of sulphides of iron from the other metallic constituents originally collected by them from the magma is also prone to take place in the case of certain metals, notably lead and zinc among the common metals.

The Expansions accompanying the Consolidation of Natural Matte.

To return to the Sudbury deposits: for every ton or 7 cubic feet of pyrrhotite produced in terms of the equation a little more than one cubic foot of extra space has to be found to compensate the expansion. This estimate excludes the expansions due to the formation of water from the hydrogen and sundry other expansions developed in the formation of pentlandite and chalcopyrite, which are also of a high order of magnitude. It is this enormous expansion which in part causes the sulphides to be often driven such long distances from the point of primary accumulation within the eruptive before they can find a convenient site for final consolidation, as well as the extensive brecciation of the deposits. It is now quite easy to understand why offset deposits, for instance, may be developed a long distance from the margin and why dykes rich in iron form favourable sites for the final resting place of the sulphides. Since the consolidation is accompanied by expansion the surrounding silicates tend to exert a pressure and produce undercooling which, as a matter of course, is followed by recalescence. Such evidence as there is on the subject of undercooling points to the conclusion that the presence of copper in the matte tends to facilitate this. We can now picture pretty clearly the nature of the process whereby the sulphides are injected into their final positions. The cooling masses of fluid sulphides as they draw near the solidifying temperature range probably tend to expand a little and thus during the undercooling period "feel" out for lines of weakness along which the great eruption can be made. At length the temperature falls to such a point that the limit of undercooling is reached and the system is in a state of thoroughly unstable equilibrium. Recalescence follows, the compressed hydrogen, for it is both hydrogen and sulphur and not only sulphur that is compressed when the ferrous hydro-sulphide forms, is probably flung from the sulphides with explosive violence and diffuses with great rapidity through the silicates reducing their iron oxides and forming water. Since this reaction is also accompanied by expansion the attacked silicates are literally burst by internal combustion of the hydrogen diffusing through the whole mass of the ferro-magnesian silicates. Meanwhile the sulphides expand as the chemical struggle between the phases of dissolved sulphur is brought into operation by the breakdown of the H_2S, and the sulphide mass begins to "grow" by "eating up" some of the iron previously solidified as oxides in the silicates, thereby effecting a greater or less replacement of the latter according to the amount of excess dissolved sulphur, which in turn depended upon the amount of H_2S previously dissolved in the matte.

The nickel and copper, whose affinity for additional sulphur develops with fall in temperature, have probably by this time attained a considerable affinity for more sulphur, and they now join in the fray, struggling with the iron in its hour of weakness, arising from the interphasic sulphur reactions, for some of its compressed and polymerized sulphur, and, tearing this asunder, cause more expansion in the formation of the pentlandite and chalcopyrite systems.

The injection process probably takes place with explosive violence and at comparatively high velocity, while it is most certainly accompanied with the development of heat. The brecciation that is such a well marked feature of many of the ore deposits at Sudbury and elsewhere is thus due to literal blasting of the rock and not due to a long-drawn-out crushing process. It is not surprising therefore to find silicate crystals broken in pieces, sulphides injected along cracks and cleavages, and the rock brecciated and cemented with sulphides.

It will be obvious from the foregoing that although the principles governing the formation of the ore-bodies apply in a general way to all the different types, there is plenty of latitude in detail. It is essentially a matter of local structure and the presence or absence of lines of weakness, for instance, as to whether a marginal accumulation of sulphides may "blow up" into a chimney-like ore-shoot situated within the eruptive itself, or give rise to a similar chimney or parallel offset a long way from the point where the preliminary concentration was effected, or if the matte were deficient in "dynamite" in the shape of compressed H_2S, the mass may freeze at the margin more or less quietly.

The analogy here drawn between compressed polymerized and undercooled H_2S in FeS and an ordinary explosive is a close one. H_2S itself is a notoriously weak compound and by building it upon itself into a dense polymerized system, the essential physico-chemical features of an explosive substance may be produced. These irresistible expansions taking place under deep seated conditions and, so to speak, slowly brought to a focus at a critical period, are full of suggestion as to the kind of physico-chemical mechanism that may give rise to local earth tremors and even earthquakes of a violent kind if the masses of material involved are of large dimensions.

It may be as well to point out at this juncture that the slope of the temperature curve proceeding outward from a cooling igneous mass of large dimensions, becomes very gradual indeed as the temperature falls but rises rather more sharply toward the interior of the igneous rock. At the làter stages of cooling the temperature at a point a mile away, say, from the margin in the surrounding country may not be very different from that at the margin itself. On the other hand a greater difference is probable, proceeding inward toward the interior of the eruptive. The precise manner in which the explosion takes place is liable to make a considerable difference to the internal arrangement of the metals within the deposit as will appear from what follows.

Liquation in Natural Matte.

It is at or about this period that the migration of copper occurs as a final effort to retard solidification of the cooler parts of the converted matte. There are several good grounds for believing that the solidifying temperature of chalcopyrite is sensibly lower than that of the other constituents of the matte. Moreover microscopic observation shows that it is the last mineral to form, in the sense of crystallization. This distinction between the formation of a system such as chalcopyrite and the process of crystallization of the system, is an important one though it is apt to be overlooked. The two processes may or may not be simultaneous and much depends on this as to the interpretation of some of the structures microscopic or otherwise that may appear in a complex mass of solidified sulphides.

The local concentration of copper in those regions of the sulphide mass that are threatened with early consolidation therefore helps to maintain fluidity a little longer in those regions and thus smooths out, as it were, the general solidification curve of the mass as a whole. The process has its analogy in the marginal liquation that occurs in alloys on casting, and it is worthy of note that it is in certain copper alloys where this phenomenon has been specially observed and studied, though it appears to be of much more general occurrence. Apart from it being one mode of expression of the Le Chatelier principle, the inner mechanics of the process are not fully understood. The subject of liquation is well worthy of more detailed investigation, for not only is it one of the mechanisms whereby important re-distributions of metal may be produced in sulphide ore deposits of certain types but it may not improbably be one of the more important factors in the magmatic differentiation of natural silicate melts.

It appears probable that the process depends to some extent on differences in osmotic pressure. The Soret principle seems never to have been thoroughly investigated for melts or solutions for temperatures in the near neighbourhood of the freezing range, where the great change from the fluid to the solid state takes place with its attendant physical changes. There are cogent reasons for believing that the osmotic pressure of a substance in solution, which depends upon freedom of ionic or molecular migration, may diminish at an immensely greater rate in the near neighbourhood of the freezing range than is the case at temperatures more remote from it.

If this is so there is no difficulty in understanding how extensive differentiation may occur just about the solidification period in accordance with the Soret principle. Metallographic investigations show that liquation takes place close to the freezing range and with amazing rapidity. Under natural conditions deep-seated melts are maintained for immense periods at temperatures close to their solidification range, so that ample time is available for effecting local concentrations of substances that are suitable for maintaining cooler marginal regions isotonic with the main interior bulk of the melt.

The Formation of Pentlandite and Chalcopyrite.

The formation of pentlandite and chalcopyrite introduces a very interesting principle in mineral synthesis. The principle, which in essence is a very simple one, consists in opposing two chemical affinities for a third substance in the presence of an insufficient quantity of it to completely satisfy the affinities of the other two. It may be described colloquially as the "cat and dog" principle since it resembles a struggle between two hungry animals for a meal insufficient to satisfy their wants. By building up the third substance into a condensed or polymerized molecule at an elevated temperature by means of one affinity and developing the other affinity on the cooling curve, a system is generated that tends to expand as the temperature falls.

We can now proceed to consider the further differentiation of the Sudbury matte. Since the presence of H_2S in the matte was the most important factor in greatly depressing the freezing range, the expulsion of the hydrogen involves a change of state of the matte from one characterized by high mobility to a comparatively viscous condition. The expulsion of hydrogen is in effect almost equivalent to quenching, but the matte now holds sulphur in solution and this element has quite a low melting point, so that the physical state of the matte at this juncture is rather to be compared with that of a viscous liquid than to that of hard cold matte. The final differentiation process and its attendant conditions may be pictured as slow crystallization from a warm viscous mass held under great pressure, the temperature falling very gradually with time. These are precisely the physical conditions under which diffusion in viscous liquids and solids takes place with the greatest ease as well as the growth of larger crystals at the expense of smaller crystals and crystallites, also interactions between the earlier and later separating constituents.

In order to understand the separation of the two generations of pentlandite and the formation of chalcopyrite it is necessary to examine their constitutions, as a matter apart from their mere ultimate chemical composition.

There are two distinct minerals included under the common name of pentlandite as described in the textbooks. These differ materially as regards their constitutions; pentlandite (*a*) is usually represented by the formula $2FeS$, NiS, and pentlandite (*b*) by the formula Ni_3FeS_5 or FeS_2, $3NiS$. Comparison of the densities of these pentlandites with those of millerite, pyrite, and troilite respectively at once reveals that the densities of the pentlandites are much lower than they should be if these formulae correctly represent the constitutions of the minerals. Without going very deeply into the matter, for lack of space, it would appear that pentlandite (*a*) may be represented graphically in some such way as this:

$$\begin{array}{l} 4FeS \leftarrow S \rightarrow Ni \\ \hphantom{4FeS \leftarrow S \rightarrow N} | \\ \hphantom{4FeS \leftarrow S \rightarrow} NiS \end{array}$$

That is to say as a solid solution of metallic nickel in NiS and FeS in which the nickel is exerting a pull on dissolved sulphur in the endeavour to form NiS by dragging it away from the iron, which in its turn is exerting a contrary pull on the same dissolved sulphur, the tug of war between the two affinities taking place, as indicated, in a solution of high viscosity, approaching solid solution. The middle S is represented above as a single atom for the sake of simplicity, but the idea underlying this interpretation of the constitution is that the middle sulphur molecule is originally polymerized or compressed by the iron sulphide and becomes broken down by the opposing pull of the affinity of nickel for sulphur that is brought to bear on it as cooling proceeds, thus generating a system of low density as compared with such simple sulphides as pyrite, millerite, etc.

Since the sulphur is dissolved in the system it is of interest also to view the problem from the point of view of solution, which resolves itself into a consideration of the behaviour of sulphur gas. Now the variations in density of sulphur gas in the free state at moderate temperatures are interpreted by the equation $S_2 \rightleftarrows S_8$, the density depending on the ratio of one form to the other. Since the affinity of the dissolved nickel increases in intensity as the temperature falls we may view the formation of such a system as pentlandite as the gradual establishment of equilibrium on the cooling curve during which a process takes place in the solution analogous to that represented in the gas dissociation equation given above. This naturally involves expansion as the temperature falls, that is to say it is the inversion of the gas temperature—density variation. It is probably exothermic since the condensation of S by FeS was considered to take place without evolution of heat, thereby tending to maintain fluidity, and illustrates both the Le Chatelier and Van t' Hoff theorems. This view is also of considerable interest because it correlates in a very direct manner the specific properties of elemental sulphur with certain properties of a group of ore minerals some of which are of immense industrial importance.

Pentlandite (*b*) is of similar type, but differs essentially from pentlandite (*a*) in that it contains no dissolved nickel in the metallic state. Using the same notation as before pentlandite (*b*) is represented as $FeS \leftarrow S \rightarrow 3NiS$.

Chalcopyrite is precisely similar and may be represented as $2FeS \leftarrow S \rightarrow Cu_2S$. In all three cases the densities are abnormally low as compared with the corresponding monometallic or di-sulphides, and the formation of the systems by means of the sulphur previously associated by solution in FeS at higher temperatures involves expansion on the cooling curve.

The following table summarizes the expansions deduced from the limiting value of sulphur as expressed in the density of pyrite.

Mineral	Constitution Diagram	Sp. Gr. of Mineral	Sp. Gr. of Dissolved S (The Middle S)	Sp. Gr. of total S	% Expansion
Pyrrhotite	$n\,FeS + S$	4·65	2·9	2·7	20
Pentlandite (*a*)	$4FeS \leftarrow S \rightarrow \underset{NiS}{\underset{\vert}{Ni}}$	4·6	1·9	2·6	11
Pentlandite (*b*)	$FeS \leftarrow S \rightarrow 3NiS$	4·54	2·5	2·55	10
Chalcopyrite	$2FeS \leftarrow S \rightarrow Cu_2S$	4·3	1·6	2·3	20

The actual figures given must not be interpreted in too literal a sense, for on the one hand the overall expansion of the mixed matte as a whole may tend to be even greater than represented if pyrite itself expands on cooling, a view in support of which some evidence can be adduced, while on the other hand the expansion in the neighbourhood of crystallization temperatures of the pentlandites and chalcopyrite may be less since it is not improbable that the commencement of their formation is during the interphasic struggle of the sulphur dissolved in FeS which entails the break in the series of solid solutions of S in FeS and the formation of pyrrhotite. During that period the principles underlying the gas dissociation equation and the melting phenomena of elemental sulphur apply, so that at the best only an approximate calculation can be made.

It is nevertheless of great interest to note that the order of consolidation is one of diminishing mean sulphur density, a reduction in density that is specially marked in the case of chalcopyrite. It is thus easy to understand why it is that some copper runs out toward the margin when pyrrhotite is being formed, why chalcopyrite is the last mineral to freeze or crystallize, its partial replacement of earlier formed sulphides, and its tendency to be squeezed into late formed fissures.

Some Suggestive Facts concerning the Sulphides of Iron.

A few additional facts in regard to the sulphides of iron may fittingly be recorded at this juncture. Pyrrhotite when freshly broken is white in colour, but it soon assumes a more or less yellow colour. This alteration in surface colour seems not to be due to oxidation but to diffusion of sulphur into the surface layers, or in other words the incipient formation of pyrite in the surface layer. The point is of interest, partly because it illustrates the Le Chatelier principle in another way, as this migration of sulphur helps to postpone oxidation a little, but principally because it tends to show that solid diffusion can take place in the natural sulphides with extraordinary ease even at low temperature and pressure and is probably the basis of the process whereby many complex mineral species are developed in ore deposits from crude mattes or sulphide precipitates.

Attempts to determine the specific gravity of FeS have failed because it dissociates in vacuo at ordinary temperatures, metallic iron and free sulphur being the products. There is thus a close resemblance between the formation of FeS and the occlusion by metals of gases. In fact the lower sulphide of iron seems to represent a kind of occlusion compound of sulphur, the sulphur being compressed by the process in much the same way as many metals occlude and condense hydrogen and other gases. The building up of the first sulphur molecule in this way seems to increase the power of the sulphur to condense itself with the result that in pyrite the compression is much greater. The occlusion of CO_2 by pyrite is a phenomenon of an allied nature and is of interest in connection with the concentration of disseminated suspensions of natural matte in a magmatic bath and the local production of carbonate gangue minerals. It has been shown experimentally that the occasionally "explosive" character of pyrite is commonly due to occlusion of CO_2 by this substance. Since the power of occluding gases commonly diminishes with fall in temperature it seems probable that the quantities retained by pyrite in the solid state are of a residual character and that natural matte may occlude or absorb considerably greater quantities of CO_2 at elevated temperatures. Such CO_2 may function as one of the gases that may help in the transport of the matte along heat or pressure gradients, while on consolidation it would be liberated and tend to give rise to carbonates among the gangue minerals.

Yet another point should be mentioned, namely that the solidifying temperature range of pyrrhotite is probably higher than that of most of the common sulphide ore minerals, but the solidifying temperature of pyrite is probably lower. Take these facts in conjunction with the oscillating changes from pyrite to pyrrhotite and vice versa that probably occur during the later stages of injection of liquid matte from a parent magma into surrounding country rock, together with the kind of migration exemplified by the behaviour ot the copper at Sudbury, and it will be evident that there is the basis for a considerable variety in the mode of distribution or zoning of sulphide minerals with respect to one another arising from this combination of circumstances.

The case of chalcopyrite is of special interest, partly on account of the great economic importance of the mineral as a source of copper, and partly because it illustrates the way in which different properties are balanced one against the other in such a manner as to materially affect the distribution of the minerals in ore deposits according to circumstances.

Both pyrite and chalcopyrite are minerals of low consolidation temperatures, but chalcopyrite probably expands to a much greater extent than pyrite on consolidation. Against this the dissociation temperature of chalcopyrite is considerably higher than that of pyrite, while chalcopyrite probably, if anything, is inclined to be a trifle more fusible than pyrite. Chalcopyrite instead of running to the margin as when pyrrhotite is formed under pressure would tend to remain in a fissure that was more or less open while pyrite with its lesser tendency to expand runs into the wall rock. Chalcopyrite is probably more sensitive to pressure variations than pyrite. From the point of view of consolidation temperature it is also of interest to contrast the two minerals. In the case of pyrite 32 parts of highly associated sulphur are used to lower the freezing point of 88 parts of pure iron matte. In the case of chalcopyrite 32 parts of highly dissociated sulphur are employed to lower the freezing point of 334 parts of mixed copper-iron matte. It is this low consolidation point coupled with the efficiency of the chemical construction for effecting the depression of the freezing range of such a *large quantity* of matte that is reponsible for the fact that chalcopyrite is the commonest of all sulphide copper minerals. Lastly the effect of alternating the concentrations of S in FeS during injection is to produce a mechanism whereby such sulphides as those of lead and zinc, which are only sparingly soluble in FeS, are easily transferred from solution in FeS into solution in the water that is produced as a product of the group of reactions, whereby crude mixed sulphides are driven from a magma into the surrounding country. Thus by combining the common ion principle for driving the lead and zinc out of the FeS and the principles governing the partition of substances between two solvents, it seems likely that lead and zinc especially may be carried a great distance from the point of deposition of iron sulphides that originally helped to assemble them and give rise to comparatively low temperature deposits presenting all the appearances of a deposit formed from aqueous solution, which is in fact the case as far as the lead and zinc are concerned.

To such an extent could this be carried that the lead and zinc need not necessarily appear as a zone above a pyritic zone in the same fissure, though this is not uncommonly the case, but could appear in what from the point of view of practical mining would be regarded as a separate lode channel. Perhaps one of the most difficult problems in mining geology in certain areas is to distinguish between lead and zinc deposits derived from igneous magmas and those derived by leaching sedimentary rocks, partly because both kinds of deposit may occur together in the same region and partly because in both cases deposition of these sulphides takes place commonly from comparatively cool aqueous solutions.

Lead and zinc so closely resemble the alkali and alkaline earth metals in important respects that their ready solubility in cool aqueous solutions is not surprising. They are thus peculiarly liable to be leached out of sedimentary formations and concentrated into ore deposits, the deposition taking place and being confined to comparatively shallow depths.

The Dissociating Power of Hydrogen.

The functions of H_2S are also of general interest and significance. The density of liquid H_2S is 0·9, that is to say it is specifically lighter than liquid H_2O although it contains the element S of twice the atomic weight of oxygen standing in a similar relation to hydrogen. By union with hydrogen sulphur is dissociated in such a way that it is presented to the metals in a finely divided state for them to assimilate and compress. Water is often described in chemical textbooks as the great dissociating agent, but it is rather hydrogen that is to be regarded as the great dissociating substance, for oxygen possesses the sulphur habit of building upon itself or polymerizing, though not perhaps in such a marked degree as sulphur. It is the unique dissociating and diffusing powers of hydrogen which make it of such importance in connection with the preliminary formation of the crude sulphides in the magma. The functions of hydrogen will be discussed more fully later.

The Formation of Polydymite and the Relationships of sundry Nickel Minerals.

One more sulphide mineral occurring at Sudbury deserves mention because it illustrates certain principles operative in the final differentiation of the matte whereby some of the more uncommon minerals in an ore deposit may develop as a result of quite local variations in the concentrations of the constituents. Polydymite is usually represented by the empirical formula Ni_4S_5 and occurs paragenetically in close association with copper-rich portions of ore deposits. Now concentration of copper implies local impoverishment in iron sulphide, and the problem confronting the excess cuprous sulphide is how to keep liquid as long as possible and form chalcopyrite so as to satisfy its increasing hunger for additional sulphur, and at the same time find ferrous sulphide in addition, with fall in temperature. The cuprous sulphide consequently exerts a pull on the FeS of the two pentlandites in the presence of some extraneous ferrous sulphide containing dissolved sulphur, giving rise to chalcopyrite on the one hand and polydymite on the other. The break-down of the pentlandites to form polydymite and the liberation of FeS to the Cu_2S can be represented as follows:

$$\begin{array}{lr} \text{1 pentlandite } (a) & 4FeS \leftarrow S \rightarrow \begin{array}{c} Ni \\ | \\ NiS \end{array} \\ \text{2 pentlandite } (b) & FeS \leftarrow S \rightarrow 3NiS \\ \hline & 6FeS \leftarrow S_3 \rightarrow \begin{array}{c} 7NiS \\ | \\ Ni \end{array} \end{array}$$

Subtract 6FeS and the remainder is $Ni_8S_{10} = 2\,(Ni_4S_5)$ = two polydymites, while 6FeS is liberated and make available for forming chalcopyrite.

The solid specific volume of two polydymites calculated from the above decomposition of pentlandites = 164, or 82 for one molecule of polydymite. The solid specific volume of polydymite of composition Ni_4S_5 by direct determination of density (4·8) = 82·5, that is to say identical within the limits of experimental error. The density of polydymite as will be evident by comparison with that of millerite as well as its constitution are distinctly peculiar, but the synthesis given above affords a complete explanation not only of the properties of the mineral itself but its paragenetic relationships as observed in the field. Compare next the thermal properties. Polydymite yields abundant sulphur in the closed tube on heating; the two pentlandites scarcely yield any, resembling pyrrhotite in this respect. By abstracting the ferrous sulphide from the systems a new system is developed from which much sulphur is readily expelled by heating. In other words ferrous sulphide exerts a stronger affinity for additional sulphur at elevated temperatures than nickel sulphide. Similarly it is evident from the properties of Cu_2S_2 and FeS_2 respectively and the order of formation of the minerals that ferrous sulphide exerts a more powerful affinity for additional sulphur than copper at elevated temperatures. Compare in this connection the dissociation temperature of FeS_2, which is about 562°C with that of Cu_2S_2 which is 358°C under like conditions. That is to say the affinity of FeS for additional S develops at a higher temperature than is the case of the other sulphides. Again, although metallic nickel unites with sulphur to form NiS and the union involves greater compression than is the case for FeS, yet when some FeS is formed it compresses additional sulphur to a greater extent than does nickel in the formation of NiS with the result that the nickel is not fully sulphurized until the lower temperatures of consolidation are reached, and even then sulphurization is not complete as can be seen by reference to the constitutions of the pentlandites. In connection with the constitution here given for pentlandite (*a*) it may be as well to point out that it is well known that artificial nickel matte dissolves metallic nickel when molten and the metal separates as such on cooling.

At Insizwa metallic nickel actually occurs embedded in the sulphides but alloyed with gold and silver which appear to "protect" it from sulphurization, thus affording substantial evidence from a natural occurrence that the affinity of ferrous sulphide for additional sulphur is so strong at fairly high temperatures that metallic nickel can exist in natural matte even in the presence of dissolved sulphur and is unable to completely satisfy its affinity for sulphur by total conversion to NiS.

Relationships between the Chemical Constitution of Minerals and their Formation in Ore Deposits.

In textbooks on mineralogy pentlandite is described as a single mineral species, but at least two, and probably more than two, distinct systems are included under the common name of pentlandite. The pentlandites, which occur in at least two generations at Sudbury, deserve more investigation than they have hitherto received, for it is probable that they embrace a series of solid solutions of nickel-iron sulphides, in which the middle S is present in varying degrees of dissociation which would manifest itself in density variations. The interest of density analysis of ore minerals in the study of ore deposits lies in the fact that sulphur, in virtue of its polymerizing properties, is a very important factor in the muscular mechanism whereby many ore deposits are driven into their positions. The usual mode of expression that ore formation is mere deposition from solution affords but a feeble and misleading notion of the processes that often operate in producing the deposits concentrated from igneous magmas. When fissures, shatter zones, or cavities are available, simple precipitation from solutions is a process common enough; but nature is not content to depend on circumstances that may be described as accidental and provides mechanisms of enormous power for "pouring," to use a metallurgist's term, her mattes into the surrounding country irrespective of the chance occurrence of mechanical lines of weakness. It is this aspect of the formation of certain kinds of ore deposits that makes it imperative that the physical chemistry not only of the ore minerals but also of the accompanying gangue minerals should be put on a sound scientific footing. It is pertinent to this disscussion to remark that the chemistry of the standard textbooks of mineralogy is for the most part the chemistry of half a century ago or more and requires extensive revision. It is the idea of the "system" rather than that of the simple chemical compound that is the basis of the constitution of so many of the ore minerals as well as their accompanying gangue minerals, and which is one of the root causes of the chemical and physical variations that are so characteristic of many sulphide and other minerals. Among ore minerals the pentlandites and the closely related sulphides of nickel illustrate this well. Millerite, NiS, has a density of 5·6, but a system of the same ultimate chemical composition derived by abstracting the iron sulphide from pentlandite (*a*), such as would occur in the formation of polydymite by the process previously outlined, has a calculated density of 4·54 only. Abstracting FeS from pentlandite (*b*) yields a system Ni_3S_4 of density only 5·25. The density of polydymite as recorded in Dana's Mineralogy ranges from 4·54 to 4·81, and for the similar mineral beyrichite, Ni_3S_4, 4·7. Mechanical impurities no doubt are responsible for many of the recorded variations in physical properties of ore minerals, but the tendency to form solid solutions of one sulphide, arsenide, etc., in another, coupled with the opposing pulls of the metallic mono-sulphides, arsenides, etc., in the scramble to secure additional quantities of the electro-negative elements to satisfy their increased affinities as these develop in different degrees on the cooling curve is a most important factor and one which urgently calls for systematic investigation. Since the electro-negative elements are often present in insufficient quantities to completely satisfy these affinities, a great variety of systems or equilibria of varying density are apt to be formed and these reflect in their physical properties the pressure and temperature conditions under which the minerals have been formed.

Chalcopyrite and the bornites may be cited as another economically important group of minerals that form a natural chemical series in much the same way as the pentlandites, though differing in detail. They may be regarded as a series of ternary alloys of Cu_2S, FeS, and S, chalcopyrite being the member of lowest freezing point and best defined composition. Owing to the tendency of Cu_2S to form solid solutions in any proportion with FeS, the bornites vary considerably in composition, but there appear to be two other fairly well defined compounds or "alloys" in the series besides chalcopyrite. These correspond to the empirical formulae:

(*a*) $3\,Cu_2S \leftarrow S \rightarrow 2\,FeS$

(*b*) $5\,Cu_2S \leftarrow S \rightarrow 2\,FeS$.

Comparison of their solid specific volumes indicates that these three principal members of the series are related to one another in much the same way as the successive members of an homologous series, such for instance as the paraffins. Thus the composition of the minerals may be of interest in connection with the determination of the probable temperature of deposition in certain kinds of ore deposits.

Reference was made to the influence of intrinsic—or internal—pressure and the closely allied phenomenon of surface tension, as a factor in producing the high density of pyrite and marcasite. The following calculations shed some interesting light on this point and on the inner nature of the principal simple sulphides of the Sudbury matte.

Internal pressure (megabars)	Ni 306,300
	Fe 239,000
	Cu 236,100
Sp. Gr. of S in millerite, NiS	3·4
ditto of S in troilite, FeS	2·9
mean ditto S in pyrrhotite, *n* FeS+S	2·7
ditto S in chalcocite, Cu_2S	2·55
ditto orthorhombic sulphur	2·03
ditto monoclinic sulphur	1·96

$$\frac{\text{Ni } 306{,}000}{\text{Fe } 239{,}000} = \frac{\text{S millerite } 3{\cdot}4}{\text{S pyrrhotite } 2{\cdot}7} = 1{\cdot}26\,; \quad \frac{\text{S millerite } 3{\cdot}4}{\text{S troilite } 2{\cdot}9} = 1{\cdot}18$$

$$\frac{\text{Ni } 306{,}000 \times 2{\cdot}03}{\text{Cu } 236{,}100 \times 1{\cdot}96} = 1{\cdot}34\,; \quad \frac{\text{S millerite } 3{\cdot}4}{\text{S chalcocite } 2{\cdot}55} = 1{\cdot}34$$

These figures suggest at once: (1) that there is an intimate relationship between the internal pressures of the metals and the Sp. Gr. of their simple sulphides; (2) that Ni assimilates and compresses the orthorhombic form of sulphur but Cu the monoclinic, while Fe assimilates orthorhombic to form pyrite but monoclinic to form marcasite; (3) the continuity of the gas laws into the solid state. These relationships are obviously of particular interest in connection with the formation of pyrrhotite from a natural nickel-copper matte and the interphasic S reactions previously discussed. The crystallographic relationships are equally interesting and suggestive but space will not permit of their discussion. There are equally interesting and suggestive relationships between the densities of the complex sulphides, the pentlandites and chalcopyrite. These may briefly be expressed as follows:

S pyrite 6·4; S millerite 3·4; $6{\cdot}4 \div 3{\cdot}4 = 1{\cdot}88 = \sqrt{3{\cdot}4}$.
Middle S pentlandite (*a*) $1{\cdot}9 = \sqrt{3{\cdot}4}$ approximately.
S chalcocite and covellite $2{\cdot}55 = \sqrt{6{\cdot}4}$.
Middle S chalcopyrite $1{\cdot}6 = \sqrt{2{\cdot}55}$ approximately.
Middle S pentlandite (*b*) $2{\cdot}5 = \sqrt{6{\cdot}4}$.

Thus there is a square-root law—or law of squares—running through the spatial concentrations of these minerals. The precise significance of these relationships is a matter requiring further investigation.

A little consideration will also make it evident that the heat dissociation of covellite is a radically different phenomenon from that of pyrite, and that chalcocite is probably of the nature of a solid solution of Cu in the covellite molecule, the metal copper thus standing in a close relationship to nickel which dissolves in nickel matte, but the solution is nothing like so stable in the solid state as is the case of copper. Silver sulphide Ag_2S seems to be similarly constituted to Cu_2S. The density of the S in marcasite appears to be about 5·4, but there are difficulties in calculating its precise value arising from what appears to be a liability on the part of the iron atom to vary in volume. $\sqrt{5\cdot4}=2\cdot3$, a figure which does not differ very widely from the densities of S in blende, ZnS, galena, PbS, and argentite, Ag_2S. These minerals, as is well known, commonly occur together and appear to contain the monoclinic variety of sulphur, that is to say the variety of largest solid specific volume. The great importance of relative solid specific volumes in the study of ore deposits will appear later.

Reverting to the internal pressure of iron, for a clear understanding of the sulphides of iron is of paramount importance in the study of ore deposits because so much of the natural smelting of the valuable metals is done on an iron matte basis, if we examine the curve of atomic volumes it will be noticed (1) that nickel has the highest internal pressure and the smallest atomic volume, (2) the atomic volume of iron in the free state seems to be abnormal and to be unexpectedly large. Compression of the iron atom and a corresponding increase in its internal pressure by means of the peculiar self-compressing properties of sulphur that develop on the cooling curve, even when it is in the free state, might thus account for the difference between the density of S in troilite, according to the convention used for the purpose of calculating S densities and the mean density of S in pyrrhotite. If next we suppose that the union of Fe with S to form troilite to take place when the internal pressure of the Fe equals the internal pressure of the S and that they mutually compress one another so that the internal pressure of the FeS system so generated is doubled from the point of view of absorbing more sulphur and compressing it accordingly, then the density of the extra sulphur would be about 5·8 or rather less than that of the additional S in pyrite. It is specially noteworthy that the discrepancy in S density between the calculated and actual magnitude is again of the same kind and proportional order of magnitude as exists between the density of S in pyrrhotite and in troilite. A somewhat similar relationship between internal pressure and the effect of carbon on iron to produce steel has been shown by Dr. Sydney W. Smith, from whose paper on "Surface Tension and Cohesion in Metals and Alloys" the internal pressures used in these calculations have been taken.*

* Journal of the Institute of Metals. No. I., Vol. XVII, 1917.

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It should be noted also that accompanying the extreme compression exhibited in the pyrite system there is developed great hardness, while on the other hand chalcopyrite—the expanded matte—is a relatively soft mineral. Again it seems highly probable that steel carbon is in the diamond or compressed form. These phenomena are thus very suggestive, for they seem to indicate that in metallurgy we owe much to the compressibility of the iron atom, while in geology it plays equally important functions in the formation of our ore deposits. In the case of marcasite it would appear that the monoclinic variety of S can neither compress itself or the iron atom to such an extent as the orthorhombic form. It would be easy to enlarge upon these aspects of the problems of ore deposition. The foregoing facts and arguments must suffice to indicate the importance of supplementing the petrographic examination of ore deposits, both macroscopic and microscopic, by methods akin to those used in metallography, otherwise the mere determination of the order of crystallization, or whether one mineral appears to be earlier or later than another, of itself sheds but a dim and uncertain light on the many factors that have operated in the formation of metalliferous deposits and the arranging of the minerals therein. There is also the other side of the problem, for the study of ore minerals and magmatic geology bids fair to throw important side lights on many of the more obscure points exhibited by metals and alloys. It thus seems eminently desirable that there should be closer collaboration between metallographers and geologists in the future for the general benefit of the metallurgical industries

(To be continued)

Sintering at Port Pirie. — An improved form of grate for Dwight-Lloyd sintering machines has been devised by Messrs. Riddell and Davison and installed at the lead-smelting plant of the Broken Hill Associated Smelters at Port Pirie. The object of the new form of grate is to make it self-cleaning, thus obviating clogging. The invention provides a continuous elevated 24in. grate-rib, with supporting cross-ribs dropped sufficiently below the tops of the grate-bars to allow cleaning tools ample clearance. The position of the grate-rib assists the release of the sinter at the discharge end of the machine. For unusually sticky charges an auxiliary tool is provided for assisting in the removal of the material, but it is seldom required.

NEWS LETTERS.

MELBOURNE,

January 7.

AUSTRALIAN LABOUR AND MINING.—If those connected with mining were asked what tends to retard the mining industry in Australia more than anything else the answer would at once be "labour." The record of 1917 shows that the biggest strike the country has known was due to the decision of the coal miners of Newcastle to take advantage of the war to wring concessions out of the coal owners. These in turn as a matter of protection asked for the right to pass the burdens imposed on them on to the consumer. That was allowed and a cool £1,500,000 additional revenue flowed into the pockets of the little group of mine owners controlling the huge collieries in the Newcastle and Maitland districts of New South Wales. This strike was engineered from purely selfish motives. It was not as if the men were poorly paid or that the working conditions were severe. Nor was the fact that the Empire was in peril unknown to them. They simply meant to hang up Australia, and they did so. A nice political dispute arose out of the trouble. This was because Justice Higgins at a later stage declared that the Prime Minister had practically said in a pencilled memorandum to him that the men's demands were to be met, and that upon His Honour declining to be fettered in any way the arbitration proceedings were transferred to the control of Justice Edmunds. History will have to disclose who is correct. If Mr. Hughes did in any way seek to direct a decision it is a pity he did not stand to his guns. Of course he says he did not and there the matter rests. One of the points of the agreement entered into with the colliery miners was that the men should not strike during the war. They observed their compact for just a year, and then went on strike again because the railway men of New South Wales had decided to down tools over the question of the introduction of the card system. Again the country was thrown into confusion and the transport of troops and food stopped. The second strike was absolutely without excuse, but the coal miners cared nothing for the necessities of the Empire. Their talk was the need for Labour solidarity, but behind everything was the determination to bring into existence a socialism regulated by Union bosses.

The issues involved in these strikes by the coal miners are of economic interest, just as are the forces that are operating silently to negative the effect of the so-called victory of the worker. What the men believe they have gained is a higher wage, and its equivalent easier working conditions. But the forcing of these concessions at once established in the minds of every statesman outside New South Wales that if their State could be relieved of dependence on the coal miners of New South Wales, nothing should be allowed to stand in the way. So the State of Victoria, when the Government of New South Wales decided to take over the mines, approached it and got control of the Pelaw Main and the Richmond Main pits, two of the biggest and best equipped coal mines anywhere in the world. They then called for men to work the two mines and secured all the volunteers they wanted. Victorian police were sent to the mines to maintain order, and the output was soon on as large a scale as shipping would accommodate. The manning of these mines was an eye-opener to the Newcastle unionist, and did more to bring him to reason than anything else. He could not complain that the men from Victoria who had taken his place were working for lower rates or under less easy conditions than those demanded. The new-comers also were unionists. What he learnt was the economic lesson, that when the interest of the State is threatened, the State will act as it did in this instance by attending to its own business, and next, that Labour will drift from other centres to one where conditions are more attractive as at Newcastle, for there living is good and the scale of wage so high that four shifts work a week means a magnificent wage. Just as this is written the news is published that the Victorian Government is handing the mines to the New South Wales Government, which contracts to supply Victoria with 1,000,000 tons of coal annually, but that does not affect the economic fact stated. Victorians are still mining the two properties.

A third disconcerting factor to the Newcastle worker is that the States are taking steps to free themselves as far as is possible from dependence on the New South Wales coalfields. Thus in Victoria a few people set to work to get the State to take in hand the development of the wonderful brown coal resources of that State. In calorific value, owing to presence of moisture, the coal is about half as efficient as the Newcastle coal, but the ease with which it can be won, its freedom from ash, and its nearness to Melbourne make the future of the industry a matter of national importance. The Peacock Government for some reason was exceedingly shy over moving in the matter, but they were so kept up to the mark that finally they appointed a committee consisting of three of the best skilled electrical engineers in Australia and the Government Geologist of Victoria to investigate the whole question. The report by these gentlemen is convincing as to the wisdom of something being done to utilize the deposits. Ignoring by-products, electricity generated at Morwell 80 miles from Melbourne can be delivered in Melbourne at a cost of approximately a farthing per unit. This is far less than the existing cost of generating electricity by Newcastle slack. With the manufacture of by-products it is believed that the cost will be much reduced. The idea is that the State as owner of the coal deposits shall generate the electricity, use it for the railways and tramways, most of which are public property, and sell power to distributing companies as does the trust operating in the province of Ontario with such public benefit. The scheme is one involving an exceedingly large outlay, but the evidence in favour of the expenditure is so complete that public opinion will force the Government to move in the direction of undertaking the work or permitting private enterprise to do so. The Legislature has laid it down as a principle that the brown coal deposits shall not be alienated, so that the expectation is that the State will carry out the programme in the interests of the community.

Before the war one group here in connection with the Deutsche Bank sought to obtain control of a portion of the deposits, but were blocked, mainly through the opposition of the Labour party. This organization with its growing strength will fight even more bitterly against private enterprise getting possession. The only way they may compromise is by permitting capital to develop the fields provided the State has control and has the right to limit profits as well as to buy out the enterprise. A portion of the Morwell field was sought to be acquired by the Amalgamated Zinc (De Bavay's) company, the statement being made that it would be possible that the electricity generated there might be used in the treatment of the zinc concentrates of Broken Hill. Now it is understood that the experiments made by some of the officials of the companies interested have not been favourable to any departure from the original plan of dealing with such concentrates at Risden near Hobart, Tasmania, where hydro-electric power will be obtained from the State power plant at the Great Lake. The reason probably is that costs are in favour of the hydro-electric scheme. The chief objection to the Victoria Government opening works at Morwell is the fear that Labour will, as at the State coal mine at Wonthaggi, refuse to be disciplined and that therefore no certainty of service can be assured. Whether this be so or not, the advantage to Melbourne and Victoria of the cheap electricity that could be won from the brown coal at Morwell is too plain to be a question of dispute. Estimates of the quantity of coal obtainable within a narrow area in Victoria is 32,000,000,000 tons. Late borings have disclosed that seams which in many places were taken at 100 ft. are over 150 ft. thick, also that the area in which they exist can be extended very greatly, so that the estimate is tremendously understated.

Wrapped in this national enterprise and that of the development of the coalfields of Newcastle as well as of mining generally is the problem of the dismally low efficiency of Australian labour. If it were not for that, much of the opposition to a State-owned project would disappear, for the financing of the scheme could be easily arranged in view of the value of the utility. The absolute cure for the "man-on-the-job" tactics of the unionist is of course the presence of a surplus of labour. With so many men away fighting the battle of the Empire this cure cannot be provided, and, until it can be supplied, the present position of affairs in Australia will be maintained. There will be discontent, strikes, indifference as to the quality of the service rendered, and demands for concessions, which add to costs. This condition of affairs is the answer to those who, like Justice Higgins, preach the value of the Court of arbitration and conciliation. Since his Honour gave his famous award over the Broken Hill mines, when he said that he felt that men with higher wages would be more contented and more loyal, events have moved in such a way as to disclose that every hope formed as to the value of the tribunal has been dissipated save in so far as it has satisfied some of the unceasing demands of labour.

The score of strikes is larger than ever. Industrial efficiency is lower than at any other time. Capital is unwilling to back new enterprises. If to create an atmosphere where conditions like these thrive then of course Justice Higgins is right. His Court has achieved a purpose, but he has to show that the State will be able to continue on these lines. He has never defined what "living" shall mean when fixing, as he always does, his basic living wage, and when granting all the concessions he has awarded he has never safeguarded them by providing that all through the contract system shall prevail on a basic living wage fixed so low that it will not do for men to loaf and skulk so as not to earn over the standard wage.

Before me at the moment lie reports relating to the Hampden-Cloncurry and other leading copper mines in North Queensland; also in respect of the decision of the Arbitration Court relating to the gold mining industry in Western Australia. They are pathetic reading when the welfare of a community is at stake. Justice Power, who is Justice Higgins's colleague in the Arbitration Court, acts up to the principle that if an industry cannot pay the living wage as fixed by the Court it is better that it shall die. He practically smashed up the mining industry in Victoria by granting concessions to the unionists that drove a number of companies into liquidation. His award on the claims of the West Australian gold miner for 44 hours a week's work and an increase in wages was brim full of recognition of the importance to the community of the gold mining industry, but equally empty of practical sympathy. The men who back it were told that if they won in the gamble the worker got none of the prize. A greater piece of judicial casuistry has never been uttered by the Australian bench. It may be a spirit of speculation that sends men to the four quarters of the earth to find gold, but the benefit of the masses when a payable field is found has never been challenged until Justice Power came on the scene. If gold had not been discovered in New South Wales, in Queensland, in Victoria, and in West Australia these countries would have remained either sheep walks or agricultural communities. The discovery of gold by Hargreaves in New South Wales and the finding of Bendigo, Ballarat, Charters Towers, Kalgoorlie, and a host of other mining centres transformed Australia and gave it a destiny. To talk of the men who backed the industry that did this as gamblers who took all the prize is nonsense. Mr. Justice Power probably knows that as well as anyone. If he does not he is to be pitied. All the same those outside Australia have to recognize the light in which a section of the Bench views the man who goes mining, as well as to take to their heart facts such as have been conveyed to them by Mr. F. A. Govett as to the economic burdens imposed on those who venture into enterprise in Australia by men of the Higgins and Power type.

Apart from Labour exactions and the burdens imposed on the gold industry, other branches of mining have not fared badly during 1917. The high price of metals enables large dividends to be paid by companies like the Barrier group and copper-mining concerns. Tin mining is now becoming a negligible industry in Australia, but the Briseis and the Pioneer among the Tasmanian deep-lead mines have been able to earn substantial profits and each has a fair life ahead. This is the case with that great old-timer, Mount Bischoff, but its career is very largely dependent on the high price of tin. There are large formations carrying tin in Australia, but the high price of labour and cost of equipping such properties prevent their development. Tin also is so erratic in occurrence when sought for in lodes that people are shy of searching for it, but the day will come when the big low-grade properties will command the capital necessary for their development.

The worst feature of Australian metalliferous mining is the lack of new finds. The only field about to come into prominence is that of Mount Read and Rosebery in northern Tasmania. There a group consisting of the Hercules, the Tasmanian Copper, and the Primrose are being developed with capital furnished by the Mount Lyell Mining & Railway Co. So far prospecting has been most encouraging and the company will start with reserves of over 1,000,000 tons of ore carrying zinc, lead, silver, gold, and copper, of a gross value, at pre-war prices, of over 9 million sterling. In north Queensland the copper industry also is developing on satisfactory lines. It would be successful if labour would let it alone. The trouble at the Mount Elliott mine is an example of the shiftless nature of the working population. There a big project was thrown into idleness. Still the mines are good, and things will work out all right in the long run. The Mount Elliott company has a bonanza in the Mount Oxide mine, which certainly is one of the richest mines of its kind in the world. Reserves are about 300,000 tons of 10% copper ore, and probably 100,000 tons of it averages 20% copper. What hangs it up is the want of a railway, but that will come.

Boring for oil is going on in Queensland and South Australia as well as in Papua, but so far unavailingly. In South Australia the bore went to over 4,000 ft., the last 1,000 ft., to the surprise of most people, through shales in which were some thin seams of coal. Still the State Geologists are dubious, though the boring crowd are sanguine. That is about the best and the worst that can be said of things.

CAMBORNE.

TINCROFT.—The largest net profit in the history of the company was the result of the working of this mine for the six months ended December 31 last, and it well illustrates the change of fortune which energetic and well directed lode development, backed by capable and far-sighted management, can do to rehabilitate a mining enterprise that is in financial straits. It may be urged that but for the high prices ruling for tin, arsenic, and wolfram, the profit (if any) would have been infinitesimal. This is true to an extent, but had the development of the mine been neglected, the good ore at the 170 fm. level on Pryce's lode would not have been found, and had the management not had the courage to lay down more plant to deal with the arsenic and wolfram, the company would not have been in a position to have taken advantage of the rise in prices of those metals. If this policy is continued, Tincroft should have a new lease of life, for a large portion of the profit now being earned will presumably be spent on development, and also on plant, which will operate in the direction of reducing working costs. For the period under review, there were 28,747 tons of ore milled, which gave a recovery of 16·77 lb. of black tin per ton, in addition to arsenic, wolfram, and copper. This black-tin produce is 2·32 lb. per ton down on the previous six months, but the explanation is that a large quantity of ore from the upper levels (previously abandoned) was sent to mill, which was high in arsenic though low in tin. The total quantity of tin concentrate sold was 215 tons, which realized £20,924, or £144. 12s. 2d. per ton. The total recovery value (tin, wolfram, arsenic, and copper) was 41s. 8d. per ton, and the working cost (including royalties, but excluding plant depreciation) 33s. 9d. per ton. The gross profit for the half-year was £11,390, and the available divisable profit was £10,292, out of which the board has declared a dividend of 2s. per share. The development was 2,379 ft., or one foot for every 12 tons of ore milled. One of the principal promising points of development appears to be the 170 fm. level in Old Tincroft, which intersected a north portion of Pryce's lode. For a width of 6 ft. and for the 108 ft. driven, this lode assays 40 to 50 lb. per ton of tin and wolfram. In the central section of the mine, Tyries' shaft is being sunk on the South lode, and bulk samples give an assay of 28 lb. of tin over a width of 6 to 7 ft. It is proposed to sink 100 ft. to the 224 fm. level and then test the lode. Other developments appear to be disclosing ore of average value.

EXCESS PROFITS DUTY.—As has been indicated in these columns from time to time, the Cornish Chamber of Mines has for many months past had pending an appeal to the Board of Referees for an increase in the Excess Profits Duty standard, which was originally fixed at 6%. This appeal, which was prepared by Mr. C. V. Thomas Chamber, has proved successful, for it is now announced that the percentage has been raised to 25 for Cornish tin and wolfram mines. For the moment, the principal gainer by this concession is East Pool & Agar, Ltd., but there are other mines which may benefit in the not distant future. Besides, too, as Mr. M. T. Taylor pointed out in his recent presidential address to the Cornish Institute of Engineers, the development of the county's mineral resources was out of the question while the Government was able to take 80% of the profits earned above 6%. Financiers would not entertain proposals to provide working capital for such a speculative proposition as Cornish tin mining while such a condition was in force. However, 25% on the working capital employed is more attractive, and should materially help in this respect, once the Treasury restrictions are removed, and labour is available.

For this, and other reasons, it is highly desirable that the Cornish mining industry should have a Joint Industrial Council in existence, representing employers and employed, which would afford an opportunity for the close study under favourable conditions by both parties of this important question of taxation. Any obstacle which may have the effect of impeding the flow of capital to Cornwall will, in turn, disadvantage the industry, and consequently, the people employed, and this truth must be made plain.

STANDARDIZED LEASES. — Mr. John Gilbert, the mineral agent of Viscount Clifden, has given the excellent suggestion of a standardized mineral lease. His idea is, that the main covenants of such a lease should be drawn up by the Department for the Development of Mineral Resources, and that the Department should have the necessary power to force mineral owners not to restrict development within their boundaries by unreasonable conditions. On the other hand, he foresees that after the close of the war, in all probability, there will be a considerable demand for setts, and among the applicants, as previous experience teaches, there will be many (whom he terms "sett boosters") who, by means of exaggerated prospectuses, will endeavour to entrap an unwary public. Even if they hold a promising property, they have often insufficient capital for the enterprise, and the result in the end is that the mine does not have a fair chance of exploitation, the shareholders lose their money, and Cornish mining is unfairly condemned. Mr. Gilbert suggests that the Cornish Chamber of Mines should investigate all applications for mine setts, but it is highly doubtful whether, in general, the legal representatives of the mineral owners would welcome such a solution.

LEVANT.—For the 16 weeks ended February 9, this mine was operated at a loss of £538, but whether in fact an actual loss on working was made can only be known to the management, if it is even known to them. I have so many times criticized the crude form of cash account issued to the shareholders, which appears to be based on the cash actually received and paid out, that I do not think it worth while to labour the matter again. Some day, perhaps, a shareholder with an inquiring mind will ask for a profit and loss account based on the receipts and expenditure. The quantity of ore stamped during the 16 weeks was 4,356 tons, compared with 6,021 tons for the previous 4 months; presumably there was some break in the machinery to account for this reduction, but the actual cause will not be known until the meeting of the shareholders. As 94 tons of tin concentrate was sold, this gives a recovery of 48 lb. of black tin per ton milled, compared with 40 lb. for the previous 4 months, so presumably higher-grade ore was broken to offset the reduction in tonnage milled. Copper and arsenic returns show an apparent fall, but presumably the sums credited for unsold stocks are conservative.

SCIENTIFIC RESEARCH.—The Research Board appointed by the Committee of the Privy Council to control the spending over the next three years of the £15,000 raised for research work on the treatment of tin and wolfram ores, as outlined in the December issue is as follows: Sir Lionel Phillips (Chairman), Mr. John G. Gilbert (Cornish Chamber of Mines), Sir

Frank Heath (Department of Scientific and Industrial Research), Sir Thomas K. Rose (Chairman of the Research Committeee of the Board), Mr. Edgar Taylor (Institution of Mining and Metallurgy), Mr. R. Arthur Thomas (Cornish Chamber of Mines), Sir Richard Threlfall (Advisory Council for Scientific and Industrial Research). Mr. Alexander Richardson is secretary and the office is at 15, Great George Street, Westminster. The Board, after consultation with their Research Committee, have authorized extended lines of research with a view to increasing the recovery of metal in the treatment of ores.

GEEVOR.—The following figures are of interest:

	Tons Milled	Tin Concentrate Sold. Tons	Recovery. lb. Black Tin per Ton	Realization Value
1916	23,754	371	35	£36,752
1917	21,521	339	35	£44,552

The north cross-cut at the 7th level has intersected the South Pig lode, which for a width of 42 inches assays 35 lb. per ton. This cross-cut will be continued to intersect the North Pig and the Northern lode. The south cross-cut at the same level has not yet intersected the Caunter lode. Good values are reported by the manager to have been met with in driving west on the North Pig lode at the 6th level.

PERSONAL.

G. H. BEATTY has been appointed general manager for the Randfontein Central Company.

L. D. CAMERON is returning to the Rayfield, Nigeria.

FRANCIS DRAKE, formerly of South Africa, has taken up work with the Air Ministry, Department of Production.

G. T. HEAL has returned from Burma.

G. W. LAMPLUGH, of the Geological Survey, has been elected president of the Geological Society.

LIEUTENANT E. G. LAWFORD, R.E., formerly of the Kyshtim, has been home from France on short leave.

W. J. PITCHFORD has been appointed manager of the New Jagersfontein diamond mines.

OLIVER THOMPSON has been appointed manager of the Minna mine and is on his way to Nigeria.

F. W. TRAPHAGEN has been appointed professor of metallurgy at the South Dakota School of Mines.

LIEUTENANT A. TREVELYAN KING is recovering from wounds.

J. T. WARNE is here from Ashanti.

ERNEST R. WOAKES is on a short visit to Spain.

W. LAURIE HAMILTON died in Johannesburg on December 18 after a long illness. In early days he was consulting engineer to Barnato Brothers. Subsequently he joined the Rand Mines group and was for some time manager of the Rose Deep. More recently he had practiced independently as a consulting mining engineer.

W. D. HOLFORD died on February 25. He was for many years a manager of collieries in Yorkshire, and he was chairman of William Cooke & Co. Ltd., wire-rope makers, Sheffield. He was one of the founders of the Midland Institute of Mining Engineers.

THOMAS TYRER, who died on February 21, was a commanding and chivalrous figure among chemical manufacturers in this country. He was one of the founders of the Society of Chemical Industry and continuously gave it his active support.

TRADE PARAGRAPHS

HENRY SOTHERAN & CO., of 140, Strand, London, W.C., have issued a catalogue of old scientific and technical books which they have on sale at present. Many of these books came from the libraries of the late Lord Justice Stirling, George Rennie, and Samuel Roberts. Among the collection we notice a number of the valuable and rare classics in mining and metallurgy.

THE MINERALS SEPARATION NORTH AMERICAN CORPORATION announces the establishment of an ore-testing works at 220, Battery Street, San Francisco. The present office and laboratory is being moved to the new address from Merchants Exchange Building.

WILLIAM JOHNSON & SONS, LTD., of Leeds, are now making plant for the manufacture of retorts used in zinc smelting. Before the war these presses used to be obtained from the Continent. The Leeds firm has specialized for many years on briquetting machinery.

HEAVY STAMPINGS, LIMITED, of Middlesbrough, have issued a new pamphlet giving particulars of their class of work. Their scope is wide and includes parts required for motors, aircraft, railways, ordnance, marine engines, textile machinery, etc. In mining machinery, they supply special parts for dredges, pumps, hoists, conveyors, etc.

HATHORN, DAVEY & CO., LTD., Leeds, have issued catalogues of their three-throw pumps and of their stereophagus pumps. The latter are intended for handling solids suspended in water, and are made according to the patents of the Hon. R. C. Parsons.

GILBERT GILKES & CO., LTD., Kendal, have recently erected a hydro-electric power station for an industrial works at Hebden Bridge, Yorkshire. Owing to the works being in a great coalfield, this installation is of some interest. Power is generated by Pelton wheel.

MATHER & PLATT, LTD., Manchester, have sent us their catalogues of their turbine pumps, which are now extensively used in mines; also of electric power machinery for mines.

GEORGE CRADOCK & CO., LTD., Wakefield, will shortly issue revised editions of their catalogue in French, Russian, Italian, and Spanish. They have recently published a useful booklet giving instructions how to use and treat Cradock's steel-wire ropes.

CROSSLEY BROTHERS, LTD., Manchester, have sent us catalogues of their gas and oil engines, suction-gas plants, etc. We note with interest a gas producer suitable for gasifying sawdust, wood waste, peat, and spent tan bark, and an oil engine employing crude and residual oils.

ED. BENNIS & CO., LTD., Little Hulton, Bolton, have issued a pamphlet describing their "coking" stokers. In this type of mechanical stoker the gaseous constituents of the coal are first distilled off and burnt, and afterward the coked coal is burnt at the back part of the grate.

ORD & MADDISON, LTD., Darlington, have sent us their calendar, which gives particulars of screening plant, ore-breakers, elevators, and hauling gear.

THE HARDINGE CONICAL MILL CO., New York, announces that the Homestake Gold Mining Co., of South Dakota, has ordered a standard 8 ft. ball-mill. The mine has over 1,000 stamps in operation. It is claimed that the ball-mill will do the work of 80 to 100 of these stamps.

THE SULLIVAN MACHINERY CO., Chicago, has issued reprints of articles, recently written by Mr. G. H. Gilman, on rock-drill and hammer-drill bits, and on an ideal drill-sharpening shop.

METAL MARKETS

COPPER.—Prices in this country are unchanged at £110–£110. 10s. for standard and £125–£121 for electrolytic. The official price in America continues at 23½ cents and there are no indications that this figure will be altered for some time to come. The world's output of copper for 1917 is reported at 1,413,056 metric tons, of which the United States contributed 856,570 tons with Japan as the next largest producer with 124,306 metric tons. While the world's total shows a small advance on 1916 the United States production has diminished slightly. In view of the labour troubles in the United States the actual result is not at all unsatisfactory, and it is interesting to note that their refinery capacity has increased by 446,428 tons since 1914. The recent fuel order is having the effect of increasing the available supplies, for it does not apply to the mining districts, while smelters and refineries are excepted. On the other hand some consumers are not exempted, so that a saving in consumption should result, while production is unchecked, always supposing that supplies to refineries are not retarded by delays in transportation. Supplies appear to be plentiful for all prospective demand and once the traffic congestion is overcome a shortage is not likely to arise. There are still complaints on the part of producers about the low official price fixed.

Average prices of cash standard copper: February 1918, £110. 5s.; January 1918, £110. 5s.; February 1917, £138. 5s. 9d.

TIN.—The market during February was characterized by considerable irregularity, and was greatly influenced by the loss of a somewhat heavy tonnage of metal at sea. To meet the situation, and to prevent the necessity of a Government control of prices with the undesirable consequences that have followed control in other metals, the Metal Exchange has introduced various regulations to meet the situation, including a voluntary scheme of rationing to be put in force between buyers and merchants. Such schemes, however, are scarcely calculated to be effective, and it is generally felt that a full Government control will have to be put in force to enable all consumers to get their share of the limited supplies.

The February market opened at £296. 5s. to £296. 10s. cash and £294. 5s.–£294. 10s. three months, and closed at £319 cash, £316 three months. America has shown great strength and has been buying in Batavia and in the Straits for direct shipment. Prices are reported for spot of 80 cents and even higher.

Naturally export permits from this country are being granted with much reluctance, it being felt that our own supplies must be conserved. The demand from France and Italy for licences is becoming insistent, as the requirements of our Allies are as urgent as our own. English tin is in strong demand.

Average prices of cash standard tin: February 1918, £311. 12s. 3d.; January 1918, £293. 6s. 2d.; February 1917, £198 19s. 3d.

LEAD.—Official prices are still £29. 10s. to £28. 10s. net; the gross equivalents of which are £30. 10s. 5d. and £29. 9s. 9d. The market in America has risen from 6·87½–7·12½ c. to 7·50 c. at the end of February. There is some continental inquiry which cannot be met.

Average prices of soft foreign lead: February 1918, £29; January 1918, £29; February 1917, £30.

SPELTER.—The official price here is again unchanged at £54–£50. The tendency in America appears easier and stocks are reported to be heavy.. Quotations are given as around 7·75 to 7·95 c. for spot and April. Trading is quiet.

Average prices of good ordinary brands: February 1918, £52; January 1918, £52; February 1917, £54. 4s. 6d.

ALUMINIUM—£225 per ton. NICKEL—£220 per ton.

QUICKSILVER.—£22 per flask of 75 lb.

BISMUTH.—12s. 6d. per lb. CADMIUM.—8s. per lb.

PLATINUM.—New 400s. per oz.; scrap 360s.

MOLYBDENITE.—105s. per unit, 90% MoS_2.

WOLFRAM.—60s. per unit, 70% WO_3.

SILVER.—The market has been comparatively uneventful this month, and the price has been steady, though with a slight decline. No action has yet been taken to fix the price by agreement between the British and American Governments.

PRICES OF CHEMICALS March 9

Owing to the war, buyers outside the controlled firms have a difficulty in securing supplies of many chemicals, and the prices they pay are often much higher than those quoted below.

		£	s.	d.
Alum	per ton	18	10	0
Alumina, Sulphate of	,,	18	10	0
Ammonia, Anhydrous	per lb.		1	10
,, 0·880 solution	per ton	33	10	0
,, Chloride of, grey	per cwt.	2	7	0
,, ,, ,, pure	,,	4	0	0
,, Nitrate of	per ton	65	0	0
,, Phosphate of	,,	115	0	0
,, Sulphate of	,,	15	10	0
Arsenic, White	,,	135	0	0
Barium Sulphate	,,	9	0	0
Bleaching Powder, 35% Cl.	,,	15	0	0
Borax	,,	37	0	0
Copper, Sulphate of	,,	67	0	0
Cyanide of Potassium, 98%	per lb.		1	0
,, ,, Sodium, 100%	,,			10
Hydrofluoric Acid	,,			7
Iodine	,,		14	0
Iron, Sulphate of	per ton	14	0	0
Lead, Acetate of, white	,,	145	0	0
,, Nitrate of	,,	65	0	0
,, Oxide of, Litharge	,,	42	0	0
,, White	,,	46	0	0
Magnesite, Calcined	,,	14	0	0
Magnesium Sulphate	,,	11	0	0
Phosphoric Acid	per lb.		1	4
Potassium Carbonate	per ton	200	0	0
,, Chlorate	per lb.		2	3
,, Chloride 80%	per ton	60	0	0
,, Hydrate, (Caustic) 90%	,,	400	0	0
,, Nitrate	,,	70	0	0
,, Permanganate	per lb.		14	0
,, Prussiate, Yellow	,,		3	6
,, Sulphate, 90%	per ton	65	0	0
Sodium Metal	per lb.		1	8
,, Acetate	per ton	130	0	0
,, Bicarbonate	,,	8	10	0
,, Carbonate (Soda Ash)	,,	7	0	0
,, ,, (Crystals)	,,	4	5	0
,, Hydrate, 76%	,,	26	0	0
,, Hyposulphite	,,	50	0	0
,, Nitrate, 95%	,,	27	0	0
,, Phosphate	,,	50	0	0
,, Silicate	,,	7	0	0
,, Sulphate (Salt-cake)	,,	2	12	6
,, ,, (Glauber's Salts)	,,	3	10	0
,, Sulphide	,,	40	0	0
Sulphur, Roll	,,	21	0	0
,, Flowers	,,	23	0	0
Sulphuric Acid, non-arsenical 144°T.	,,	4	5	0
,, non-arsenical 95%	,,	7	0	0
Superphosphate of Lime, 18%	,,	5	0	0

STATISTICS.

Production of Gold in the Transvaal.

	Rand	Else-where	Total	Value
	Oz.	Oz.	Oz.	£
Year 1912	8,753,563	370,731	9,124,299	38,757,560
Year 1913	8,430,998	363,826	8,794,824	37,358,040
Year 1914	8,033,567	344,570	8,378,139	35,588,075
Year 1915	8,772,919	320,752	9,073,671	38,627,461
Year 1916	8,971,359	324,179	9,295,538	39,484,934
January 1917	756,997	25,637	782,634	3,324,418
February	696,955	24,366	721,321	3,063,976
March	760,598	26,496	787,094	3,343,363
April	717,598	25,180	742,778	3,155,121
May	753,531	26,034	779,385	3,310,618
June	732,799	26,925	759,724	3,227,101
July	731,848	25,991	757,839	3,219,094
August	731,405	25,253	756,658	3,214,079
September	712,881	25,350	738,231	3,135,807
October	724,846	26,444	751,290	3,191,279
November	698,271	24,568	722,839	3,070 426
December	697,137	25,282	722,419	3,068,639
Year 1917	8,714 866	307,527	9,022,493	38,323,921
January, 1918	694,121	19,991	714,182	3,033,653
February	637,571	22,188	659,759	2,802,477

Natives Employed in the Transvaal Mines.

	Gold mines	Coal mines	Diamond mines	Total
January 31, 1917	188,624	11,611	5,591	205,826
February 28	191,095	11,568	6,268	208,931
March 31	190,028	11,494	6,620	208,142
April 30	185,975	11,435	6,314	203,724
May 31	180,168	11,432	5,805	197,405
June 30	175,727	11,258	5,369	192,354
July 31	171,653	11,381	5,223	188,257
August 31	170,817	11,401	5,028	187,246
September 30	171,334	11,601	4,791	187,726
October 31	170,531	11,841	4,620	186,792
November 30	169,083	11,633	4,620	185,336
December 31	172,740	11,695	4,593	189,028
January 31, 1918	176,424	11,469	4,715	192,608
February 28	181,066	11,243	4,825	197,134

Cost and Profit on the Rand.

Compiled from official statistics published by the Transvaal Chamber of Mines. The profit available for dividends is about 60% of the working profit.

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
January 1917	2,337,066	26 10	18 8	7 11	941,520
February	2,153,691	27 3	19 2	7 10	841,259
March	2,430,590	26 7	19 0	7 4	879,351
April	2,235,833	27 2	19 2	7 8	857,710
May	2,405,855	26 4	18 7	7 5	887,527
June	2,288,426	26 11	19 2	7 7	867,639
July	2,294,668	26 11	19 0	7 7	869,577
August	2,301,892	26 9	19 0	7 6	859,517
September	2,195,884	27 5	19 4	7 9	848,096
October	2,280,461	26 10	19 5	7 2	814,211
November	2,156,814	27 4	19 11	7 2	775,502
December	2,130,510	27 7	20 0	7 4	783,729

Production of Gold in Rhodesia and West Africa.

	Rhodesia.		West Africa.	
	1917	1918	1917	1918
	£	£	£	£
January	296,113	253,807	131,665	107,863
February	289,734	—	104,892	—
March	300,183	—	158,727	—
April	297,977	—	123,825	—
May	299,271	—	121,104	—
June	302,195	—	114,489	—
July	288,731	—	142,017	—
August	294,359	—	130,278	—
September	291,367	—	127,168	—
October	289,978	—	126,295	—
November	275,829	—	126,915	—
December	270,616	—	122,602	—
Total	3,495,391	253,807	1,529,977	107,863

West Australian Gold Statistics.

	Reported for Export oz.	Delivered to Mint oz.	Total oz.	Total value £
January 1917	*	83,962	*	*
February	*	81,810	*	*
March	*	76,171	*	*
April	*	82,144	*	*
May	*	78,165	*	*
June	*	82,600	*	*
July	*	81,166	*	*
August	*	80,181	*	*
September	*	81,761	*	*
October	*	73,901	*	*
November	*	80,642	*	*
December	*	78,793	*	*
January, 1918	*	73,703	*	*
February	*	76,987	*	*

* By direction of the Federal Government the export figures will not be published until further notice.

Australian Gold Returns.

	Victoria.		Queensland.		New South Wales	
	1916	1917	1917	1918	1917	1918
	£	£	£	£	£	£
January	89,900	67,627	50,150	47,600	29,000	25,000
February	76,500	65,450	63,200	—	26,000	—
March	103,600	74,794	61,200	—	41,000	—
April	60,000	75,139	62,470	—	21,000	—
May	119,500	65,623	65,450	—	28,400	—
June	86,000	64,180	73,100	—	24,600	—
July	100,600	68,937	71,820	—	44,000	—
August	66,800	101,428	74,800	—	21,000	—
September	115,100	61,701	64,180	—	20,000	—
October	81,400	33,533	54,400	—	47,000	—
November	94,000	75,912	42,380	—	29,000	—
December	96,600	...	64,170	—	19,000	—
Total	1,090,000	789,585	780,720	47,600	349,000	25,000

Production of Gold in India.

	1915	1916	1917	1918
	£	£	£	£
January	201,255	192,150	190,047	176,030
February	195,970	183,264	180,904	—
March	194,350	186,475	189,618	—
April	196,747	192,208	185,835	—
May	199,786	193,604	184,874	—
June	197,447	192,469	182,426	—
July	197,056	191,404	179,660	—
August	197,984	192,784	181,005	—
September	195,952	192,330	183,630	—
October	195,531	191,502	182,924	—
November	192,714	192,298	182,388	—
December	204,590	205,164	190,852	—
Total	2,369,382	2,305,652	2,214,163	176,030

Daily London Metal Prices

Copper, Lead, Zinc, Tin, in £ per long ton. Silver in pence per standard ounce.

	Copper Stan-dard	Copper Electro-lytic	Copper Best Select'd	Soft For'n Lead	Zinc	Tin Stan-dard	Silver
Feb.	£	£	£	£ s.	£ s.	£ s. d.	d.
12	110	125	123	29 10	54 0	311 10 0	42⅞
13	110	125	123	29 10	54 0	315 0 0	42¾
14	110	125	123	29 10	54 0	323 0 0	42¾
15	110	125	123	29 10	54 0	323 0 0	42¾
18	110	125	123	29 10	54 0	317 0 0	42⅝
19	110	125	123	29 10	54 0	314 0 0	42⅝
20	110	125	123	29 10	54 0	313 0 0	42⅝
21	110	125	123	29 10	54 0	315 0 0	42⅝
22	110	125	123	29 10	54 0	314 0 0	42½
25	110	125	123	29 10	54 0	314 0 0	42½
26	110	125	123	29 10	54 0	318 0 0	42½
27	110	125	123	29 10	54 0	318 0 0	42½
28	110	125	123	29 10	54 0	319 0 0	42½
Mar.							
1	110	125	123	29 10	54 0	319 0 0	42½
4	110	125	123	29 10	54 0	318 0 0	42½
5	110	125	123	29 10	54 0	319 0 0	42½
6	110	125	123	29 10	54 0	319 0 0	42½
7	110	125	123	29 10	54 0	319 0 0	42½
8	110	125	123	29 10	54 0	319 0 0	42¾
11	110	125	123	29 10	54 0	320 0 0	42¾
12	110	125	123	29 10	54 0	322 0 0	43

Imports of Ores and Metals into United Kingdom.

These figures now include Government imports.

* Statistics not published. Long tons.

	Year 1916	Year 1917	Jan 1918
	Tons	Tons	Tons
Iron Ore	6,905,936	*	*
Copper Ore	34,492	*	*
,, Matte and Precipitate	43,839	28,241	2,226
,, Metal	111,412	142,778	21,036
Copper and Iron Pyrite	951,206	*	*
Tin Concentrate	33,912	*	*
,, Metal	33,646	27,143	3,147
Manganese Ore	439,509	*	*
Lead, Pig and Sheet	157,985	147,124	23,849
Zinc (spelter)	53,324	76,105	10,981
	lb.	lb.	lb.
Quicksilver	2,556,214	2,172,434	259,350

Exports of Copper from United States

1917	Long tons	1917	Long tons	1918	Long tons
January	25,540	July	38,127	January	58,040
February	24,937	August	45,304	February	—
March	51,246	September	30,493	March	—
April	79,001	October	39,115	April	—
May	45,241	November	38,638	May	—
June	39,816	December	35,000	June	—
Total	265,783	Total 1917	484,120	Total 1918	58,040

Outputs of Tin Mining Companies.

In Tons of Concentrate.

	Year 1917 Tons	Jan. 1918 Tons	Year 1918 Tons
Bisichi (Nigeria)	278	30	30
Briseis (Tasmania)	237	30	30
Dolcoath (Cornwall)	863	—	—
East Pool (Cornwall)*	1,012	92	92
Gopeng (F.M.S.)	1,039	81	81
Malayan Tin (F.M.S.)	828	62	62
Mongu (Nigeria)	571	35	35
Naraguta (Nigeria)	503	45	45
N. N. Bauchi (Nigeria)	550	50	50
Pahang (F.M.S.)	2,612	174	174
Rayfield (Nigeria)	660	65	65
Renong (Siam)	1,023	57	57
Siamese Tin (Siam)	808	144	144
South Crofty (Cornwall)*	694	60	60
Tekka-Taiping (F.M.S.)	422	21	21
Tongkah Harbour (Siam)	1,229	125	125
Tronoh (F.M.S.)	1,046	104	104

* Including Wolfram.

Stocks of Tin.

Reported by A. Strauss & Co. Long tons.

	Dec. 31, 1917	Jan. 31, 1918	Feb. 28, 1918
	Tons	Tons	Tons
Straits and Australian, Spot	2,084	3,099	2,228
Ditto, Landing and in Transit	1,875	400	475
Other Standard, Spot and Landing	521	498	482
Straits, Afloat	*4,403	*4,085	*3,370
Australian, Afloat	—	—	—
Banca, on Warrants	—	—	—
Ditto, Afloat	*2,120	*2,300	*2,900
Billiton, Spot	—	—	—
Ditto, Afloat	*306	*300	*300
Straits, Spot in Holland and Hamburg	—	—	—
Ditto, Afloat to Continent	*500	*500	*500
Afloat for United States	*6,695	*7,579	*9,555
Stock in America	497	767	197
Total Stock	19,301	19,528	20,007

* Estimated.

Shipments and Imports of Tin

Reported by A. Strauss & Co. Long tons.

	Year 1916	Year 1917	Feb. 1918	Year 1918
	Tons	Tons	Tons	Tons
Shipments from:				
Straits to U.K.	27,157	28,099	*1,000	*,2500
Straits to America	25,943	24,977	*3,500	*6,500
Straits to Continent	8,487	9,290	*500	*1,000
Australia to U.K.	2,537	349	—	—
U.K. to America	14,863	12,890	178	748
Imports of Bolivian Tin into Europe	15,116	19,209	1,086	2,294
Deliveries in U.K.	16,862	15,142	1,595	3,174
,, ,, Holland	943	1,714	—	*71

* Estimated.

Nigerian Tin Production.

In long tons of concentrate of unspecified content.

Note. These figures are taken from the monthly returns made by individual companies reporting in London, and probably represent 85% of the actual outputs.

	1913	1914	1915	1916	1917	1918
	Tons	Tons	Tons	Tons	Tons	Tons
January	466	485	417	531	667	642
February	427	469	358	528	646	—
March	510	502	418	547	655	—
April	430	482	444	486	555	—
May	360	480	357	536	509	—
June	321	460	373	510	473	—
July	357	432	455	506	479	—
August	406	228	438	498	551	—
September	422	289	442	535	536	—
October	480	272	511	584	578	—
November	446	283	467	679	586	—
December	478	326	533	654	644	—
Total	5,103	4,708	5,213	6,594	6,879	642

Production of Tin in Federated Malay States.

Estimated at 70% of Concentrate shipped to Smelters.
Long Tons. No figures published since June, 1917.

	1913	1914	1915	1916	1917
	Tons	Tons	Tons	Tons	Tons
January	4,121	4,983	4,395	4,316	3,558
February	3,823	3,555	3,780	3,372	2,755
March	3,562	3,839	3,653	3,696	3,286
April	4,066	4,087	3,619	3,177	3,251
May	4,319	4,135	3,823	3,729	3,413
June	3,993	4,303	4,048	3,435	3,489
July	4,245	4,582	3,544	3,517	...
August	4,620	3,591	4,046	3,732	...
September	4,379	3,623	3,932	3,636	...
October	4,409	3,908	3,797	3,681	...
November	3,976	4,085	4,059	3,635	...
December	4,614	4,351	4,071	3,945	...
	50,127	49,042	46,767	43,871	19,752

Sale of Tin Concentrate at Redruth Ticketings.

	Long tons	Value	Average
July 2, 1917	159½	£21,661	£135 16 1
July 16	144½	£18,896	£130 19 11
July 30	168	£23,225	£138 5 0
August 13	160¼	£21,757	£135 15 4
August 27	156½	£21,429	£136 18 6
September 10	160¼	£21,784	£135 18 9
September 24	153	£21,448	£140 3 9
October 8	160½	£22,160	£138 11 6
October 22	153	£21,712	£141 18 2
November 6	144¼	£21,063	£146 0 5
November 19	156	£24,737	£158 11 6
December 3	148	£24,609	£165 5 6
December 17	148½	£25,620	£172 10 7
December 31	151¾	£23,450	£154 10 8
Total, 1917	4,186	£561,003	£134 0 0
January 14, 1918	141	£23,563	£167 2 3
January 28	171½	£28,976	£168 19 2
February 11	166½	£29,674	£178 4 6
February 25	156½	£28,213	£180 18 4

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS:	Mar. 7, 1917 £ s. d.	Mar. 7, 1918 £ s. d.
RAND:		
Bantjes	7 6	3 6
Brakpan	4 16 3	5 0 0
Central Mining (£8)	6 10 0	6 3 9
Cinderella	4 9	4 3
City & Suburban (£4)	1 19 6	1 0 0
City Deep	4 2 6	2 19 6
Consolidated Gold Fields	1 8 0	1 16 6
Consolidated Langlaagte	1 5 0	18 0
Consolidated Main Reef	17 3	15 6
Consolidated Mines Selection (10s)	1 0 9	1 10 6
Crown Mines (10s.)	2 18 9	1 15 0
Daggafontein	12 9	1 10 0
D. Roodepoort Deep	11 3	10 0
East Rand Proprietary	11 3	5 9
Ferreira Deep	1 3 9	14 6
Geduld	2 1 6	2 0 6
Geldenhuis Deep	1 3 9	14 6
Gov't Gold Mining Areas	2 15 0	3 13 0
Heriot	2 7 6	1 10 0
Jupiter	7 6	5 9
Kleinfontein	1 2 3	1 0 6
Knight Central	9 0	4 0
Knight's Deep	1 10 0	9 6
Langlaagte Estate	17 6	14 0
Main Reef West	3 6	—
Meyer & Charlton	5 11 3	5 11 3
Modderfontein (£4)	19 3 9	23 2 6
Modderfontein B	7 10 0	8 6 3
Modder Deep	6 18 9	7 10 0
Nourse	1 1 3	18 9
Rand Mines (5s.)	3 10 6	2 16 3
Rand Selection Corporation	3 10 0	4 13 9
Randfontein Central	12 0	11 9
Robinson (£5)	18 9	16 3
Robinson Deep A (1s.)	1 13 9	1 3 9
Rose Deep	1 0 6	18 9
Simmer & Jack	7 0	5 0
Simmer Deep	4 0	3 3
Springs	2 14 6	3 14 6
Sub-Nigel	1 3 9	1 6 3
Van Ryn	1 18 0	1 0 6
Van Ryn Deep	3 6 3	3 11 3
Village Deep	1 8 9	1 0 0
Village Main Reef	16 3	12 6
Witwatersrand (Knight's)	2 13 9	1 12 0
Witwatersrand Deep	1 0 0	7 6
Wolhuter	9 6	6 6
OTHER TRANSVAAL GOLD MINES:		
Glynn's Lydenburg	16 3	1 0 0
Sheba (5s.)	1 3	1 0
Transvaal Gold Mining Estates	1 1 3	16 6
DIAMONDS IN SOUTH AFRICA:		
De Beers Deferred (£2 10s.)	13 0 0	12 17 6
Jagersfontein	4 2 6	4 6 3
Premier Deferred (2s. 6d.)	7 10 0	7 7 6
RHODESIA:		
Cam & Motor	9 9	11 6
Chartered British South Africa	12 0	15 0
Eldorado	9 0	7 6
Falcon	15 3	1 5 9
Gaika	9 6	1 0 0
Giant	6 6	8 3
Globe & Phœnix (5s.)	1 12 6	1 10 6
Lonely Reef	1 8 3	1 14 6
Rezende	9 6	4 10 0
Shamva	1 2 0	1 15 0
Wanderer (3s.)	1 3	1 6
Willoughby's (10s.)	4 0	5 3
WEST AFRICA:		
Abbontiakoon (10s.)	5 3	4 0
Abosso	7 9	7 9
Ashanti (4s.)	18 6	1 1 3
Prestea Block A	6 0	4 3
Taquah	16 6	16 0
WEST AUSTRALIA:		
Associated Gold Mines	4 0	3 3
Associated Northern Blocks	3 0	2 6
Bullfinch	1 9	1 9
Golden Horse-Shoe (£5)	1 13 9	2 1 3
Great Boulder Proprietary (2s.)	10 9	13 0
Great Boulder Perseverance	1 0	—
Great Fingall (10s).	1 0	2 0
Ivanhoe (£5)	2 0 0	1 13 9
Kalgurli	8 6	9 3
Sons of Gwalia	13 3	9 6

GOLD, SILVER, *cont.*	Mar. 7, 1917 £ s. d.	Mar. 7, 1918 £ s. d.
OTHERS IN AUSTRALASIA:		
Mount Boppy, New South Wales	5 0	7 6
Talisman, New Zealand	7 6	16 3
Waihi, New Zealand	1 13 6	1 18 0
Waihi Grand Junction, New Z'lnd	15 9	17 0
AMERICA:		
Alaska Treadwell (£5), Alaska	2 10 0	—
Buena Tierra, Mexico	8 6	10 0
Camp Bird, Colorado	5 6	7 9
Casey Cobalt, Ontario	6 0	9 0
El Oro, Mexico	7 6	9 9
Esperanza, Mexico	8 3	[illegible] 9
Frontino & Bolivia, Colombia	13 0	13 9
Le Roi No. 2 (£5), British Columbia	10 0	7 6
Mexico Mines of El Oro, Mexico	4 10 0	5 12 6
Oroville Dredging, California	15 6	19 6
Plymouth Consolidated, California	1 1 3	1 2 6
St. John del Rey, Brazil	15 0	18 0
Santa Gertrudis, Mexico	8 9	13 6
Tomboy, Colorado	1 0 0	19 0
RUSSIA:		
Lena Goldfields	2 5 0	1 5 0
Orsk Priority	1 1 3	16 3
INDIA:		
Champion Reef (2s. 6d.)	6 0	5 6
Mysore (10s.)	3 2 6	2 18 9
Nundydroog (10s.)	1 5 0	1 5 0
Ooregum (10s.)	19 6	18 9
COPPER:		
Arizona Copper (5s.), Arizona	2 2 6	2 6 3
Cape Copper (£2), Cape Province	4 0 0	2 15 0
Chillagoe (10s.), Queensland	3	1 3
Cordoba (5s.), Spain	3 6	3 0
Great Cobar (£5), N.S.W.	2 0	2 0
Hampden Cloncurry, Queensland	1 13 9	1 10 3
Kyshtim, Russia	2 11 3	1 0 0
Messina (5s.), Transvaal	10 0	[illegible] 6
Mount Elliott (£5), Queensland	5 10 0	3 15 0
Mount Lyell, Tasmania	1 5 0	1 8 3
Mount Morgan, Queensland	1 11 9	1 14 6
Rio Tinto (£5), Spain	61 7 6	64 5 0
Sissert, Russia	1 7 6	17 6
Spassky, Russia	1 17 6	1 1 3
Tanalyk, Russia	2 7 6	1 0 0
Tanganyika, Congo and Rhodesia	2 8 9	3 10 0
LEAD-ZINC:		
BROKEN HILL:		
Amalgamated Zinc	1 10 6	1 11 6
British Broken Hill	1 7 6	1 18 9
Broken Hill Proprietary (8s.)	2 6 0	3 7 6
Broken Hill Block 10 (£10)	1 0 0	1 15 0
Broken Hill North	2 6 0	3 0 3
Broken Hill South	8 2 6	10 10 0
Sulphide Corporation (15s.)	1 5 0	1 7 0
Zinc Corporation (10s.)	14 6	1 2 9
ASIA:		
Burma Corporation	3 15 0	4 5 6
Irtysh Corporation	2 4 6	1 2 6
Russian Mining	1 2 6	10 0
Russo-Asiatic	5 8 9	2 8 9
TIN:		
Aramayo Francke, Bolivia	1 10 0	1 18 9
Bisichi, Nigeria	11 0	15 0
Briseis, Tasmania	4 9	5 6
Dolcoath, Cornwall	[illegible] 6	12 6
*East Pool, Cornwall	1 11 3	1 4 9
Ex-Lands Nigeria (2s.), Nigeria	1 6	2 0
Geevor (10s.) Cornwall	10 0	19 0
Gopeng, Malay	1 10 0	1 16 3
Ipoh Dredging, Malay	13 9	16 9
Malayan Tin Dredging, Malay	1 18 9	2 2 6
Mongu (10s.), Nigeria	9 9	15 0
Naraguta, Nigeria	12 6	18 0
N. N. Bauchi Pref. (10s.), Nigeria	8 0	12 6
Pahang Consolidated (5s.), Malay.	9 6	13 6
Rayfield, Nigeria	7 6	12 9
Renong Dredging, Siam	2 5 0	2 11 3
Ropp (4s.), Nigeria	17 0	1 0 6
Siamese Tin, Siam	2 7 6	3 2 6
South Crofty (5s.), Cornwall	15 0	1 10 9
Tekka, Malay	3 0 0	3 12 6
Tekka-Taiping, Malay	3 0 0	3 15 0
Tronoh, Malay	1 7 0	1 13 9

* £1 shares split into 4 of 5s. each in August 1917.

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also reviews of new books, and abstracts of the yearly reports of mining companies.

PRECIPITATION OF GOLD BY CHARCOAL

In our last issue, Mr. W. B. Blyth referred to the method of precipitation of gold from cyanide solutions introduced by Messrs. K. Byron Moore aud H. R. Edmands at the Yuanmi mine, West Australiá, and mentioned that it was being employed in Rhodesia. The Report of the Department of Mines of West Australia for 1916, just received, contains a description of the Yuanmi plant, written by H. G. Walton and R. C. Wilson.

The first stage in the process is the preparation of the charcoal. The best results are obtained from charcoal recovered from the water seal of a downdraught gas-producer in use on the mine, in which local mulga is used as fuel. This charcoal is a waste product. The precipitating agent in charcoal is occluded gas. Quenching while red hot produces the best results, and probably the reason the waste gas-producer charcoal has given the highest recovery of gold per lb. of charcoal used, is that a large amount of gas is drawn through the char in the hearth of the producer before the particles drop red hot into the water seal. The charcoal is washed free of ash in a cradle arrangement, in a tank of water, and the clean product is placed in a cylindrical mill and crushed in one-third of its weight of water with steel balls for about 18 hours. The degree of fineness to which charcoal should be crushed must be determined by comparative precipitation tests; all must pass through a 150 mesh screen. Experiments have shown that wet crushed charcoal has five times the precipitating power of dry crushed charcoal, and the finer particles have a greater efficiency than the coarser particles, even of 150 mesh product. The charcoal sludge is fed into three Moore-Edmands precipitation units by means of a centrifugal pump. The precipitation units are equipped with filter frames of the vacuum type, spaced 4 in. centres. The agitation of cyanide solution, which gravitates to the units, and of the charcoal sludge, is effected by propellers attached to a spindle which revolves in the lower portion of the precipitation unit at 190 revolutions per minute. The units are charged with about 300 lb. of charcoal sludge (dry weight). Before cake-forming is started, the pulp is thoroughly agitated by the propellers. To prevent channeling while the process is going on, the vacuum is periodically shut off, the cakes dropped, and the sludge thoroughly agitated. The capacity of charcoal to precipitate gold soon decreases. The process is therefore carried on in two or more stages. The cyanide solution drawn off from the first unit is delivered by the vacuum pump to a storage tank, whence it flows to the second precipitation unit, and so on to a third unit if necessary. When the charcoal in the first unit has lost its power for rapid precipitation the charcoal in the second unit is still little impaired. The flow of solutions is then reversed, and the maximum precipitating power from a given quantity of charcoal obtained. The following is a typical day's run: Head value of solution, 20s. 3d. per short ton; tail value of solution from 1st unit, 6s. 7d. equal to 67·5% precipitation; tail value of solution from 2nd unit, 9·5d. equal to 96·1% precipitation; tail value of solution from 3rd unit, trace, equal to 99·9% precipitation. The amount of gold precipitated per ton of mulga charcoal averages about 770 oz.

There is never any trouble in passing all the solutions from the plant through the precipitating units; their capacity has not been definitely determined, but exceeds 300 tons daily. When the precipitating power of the charge in the units is nearing exhaustion, as indicated by assay, the plant is cleaned up. A charge lasts from 10 to 20 days, according to the amount of gold contained in the solutions passing through the units. Precipitation is not directly proportional to the value of the solutions, but rich solutions more speedily exhaust the power to precipitate rapidly. To clean up, the vacuum is released, the cakes dropped, and emulsified by the propellers. The sludge is run into a concrete tank beneath the units, and the moisture is removed in a clean-up press of the ordinary type. While damp enough still to be adhesive the precipitate is placed in lumps in braziers constructed of strong wire screening, ¾ in. aperture, and burned to an ash, a process which takes about 1½ days and is carried out in a lock-fast chamber. There is practically no loss by dusting or volatilization. The ash which remains to be smelted amounts to about one-third of the weight of charcoal fed into the units. There is no trouble in smelting the ash with the usual fluxes, and the wear on crucibles is much less than from zinc precipitate. The smelted gold, without refining, is remarkably pure. From clay-lined pots gold worth £4. 2s. 6d. per oz. is obtained, and from graphite pots the gold is worth about £4. 1s. per oz. Using zinc as a precipitant, the bullion produced from the same ore, after considerable refining, could only be brought up to from £3. 8s. to £3. 12s. per oz. The finer gold obtained from charcoal effects a considerable saving in bank and mint charges. Prior to the use of charcoal as a precipitant this section of the treatment plant was a constant source of anxiety. The trouble in precipitation arises from the presence of antimony and arsenic in the ore. With the ordinary zinc shaving as a precipitant, tail solutions from the boxes were most erratic, and at times alarmingly high. Experiments indicated that better work would be obtained from zinc used as a powder, and to carry out the work cheaply and effectively the mine metallurgists, Messrs. K. Byron Moore and H. R. Edmands, designed the precipitation units now in use. The use of charcoal was evolved by the same metallurgists as a war-time economy. The process has been in operation for about a year, and has proved a complete success metallurgically and financially. At the present price of zinc the saving effected is about 1s. per ton of ore treated. A further saving has been brought about by the lowering of the final residual value of the ore, as box-tail solutions from zinc-boxes, part of which are lost, could never be reduced to the figure now obtained by charcoal precipitation.

There is one other advantage about the process that is worth mentioning, and that is the whole of the charcoal in a precipitation unit is burnt and any shortage of gold can be immediately detected, whereas when a zinc-box is cleaned up a portion of the zinc carrying gold is put back into the box, and as it is not an easy matter to determine just how much gold has been put back a shortage in gold is not readily detected. The clean-up is much simpler and cheaper than the clean-up of an ordinary zinc-box. This will be clear from the following comparison: Clean up of zinc-box: (1) Take out all zinc from the boxes, clean out boxes, and put back portion of the zinc and send remainder to acid tubs; (2) add sulphuric acid till all zinc attacked; (3) siphon off acid; wash and dry zinc slime; (4) roast slime; (5) flux and smelt. Clean up of charcoal dust. (1) Run out charcoal sludge and dry sufficiently to make into balls; (2) burn charcoal balls (these burn quite readily); (3) add flux to ash and smelt.

The advantages of charcoal dust precipitation may be summarized as follows. Charcoal costs little or nothing; no acid is required; purer gold is obtained; any shortage in gold is readily detected.

[Reference should also be made to the paper by H. R. Edmands, March 7, Institution of Mining & Metallurgy.—EDITOR].

STEEL MANUFACTURE IN INDIA.

On January 17, H. M. Surtees Tuckwell read a paper before the Royal Society of Arts giving an outline of the history of the Tata iron and steel works in India, and of the proposed expansions. Previously to Mr. Tata's embarkation on this enterprise, two earlier attempts had been made to establish an iron and steel industry in India. The first attempt to establish an iron and steel industry on modern lines in India was made by Joseph Marshall Heath, a retired Madras civilian, who obtained a grant from the directors of the East India Company and established works at Porto Novo, on the Madras coast, in 1830. The expenses of buildings and experiments exhausted his funds, and the Government granted him a loan. He installed furnaces capable of producing forty tons of pig-iron weekly, and his intention was to manufacture bar iron and export to England in competition with Swedish iron. The venture, however, was not a success. In 1853 a new company, the East India Iron Company, took over the undertaking, which, eventually stopped altogether in 1874. The second attempt was in 1875, when the Barakar Iron Works Company started on the Jherria coalfields, 143 miles north-west of Calcutta. They likewise failed, and closed in the same year. The Government restarted operations in 1881, and in 1889 made over the concern to the Bengal Iron and Steel Company, which has successfully produced pig iron ever since. In 1905 the Bengal Company opened a steel department, but it was found there was not sufficient demand for small steel sections at that time to make continuous rollings of any one section to work economically. Manufacturing under such conditions resulted in a considerable loss of money, and the steel department was closed down in twelve months after starting. The company, however, continued to make cast iron articles and specializes in foundry pig-iron.

The third attempt was that of the Tata Iron and Steel Company, which was formed in 1907, by Jamsetji Nusservanji Tata, a member of the Parsee community who had previously become famous for the establishment of cotton spinning at Nagpur. Mr. Tata first obtained a concession to work the Lokara ore with Warora coal; this coal proved unsuitable for coking, and he relinquished the scheme. At the end of the last century he visited England, and on his return to India obtained permission to work the Chanda iron ore deposits. In 1902 he visited America, obtained expert advice, and among others, saw Julian Kennedy, and engaged C. P. Perin, a New York mining engineer, whose associate, C. M. Weld, left for India shortly afterward. Eventually Mr. Weld located one of the richest iron ore deposits in the world, in the Rajara Hills, Central Provinces, and in the Dhullee Hill nearby. Finally, through Mr. Perin's and Mr. Weld's investigations, the deposits at Gurumaishini in Mourbhanj were found to offer the most favourable conditions for immediate operation, these being materially influenced by the proximity of the Jherria coalfields. Prospecting and mining leases were obtained from the Maharaja of Mourbhanj, conditionally upon the total area taken up not exceeding twenty miles. Prospecting continued till 1909, when a thirty years' mining lease with option for renewal for a similar period was obtained by the Tata Iron and Steel Company. Government sanction was secured in 1910, and the Tata firm now has concessions for Gurumaishini and other iron ores in Mourbhanj, Dhullee, Rajara, and Chanda iron ore in Central Provinces, acquiring also its own manganese mines at Ramramah, Central Provinces. Samples of coal from different seams in the Jherria coalfield were sent to America and Europe for analysis and coking test, and it was found that while they contained a high percentage of ash, they yielded sufficently hard coke for blast-furnace purposes. Limestone of excellent quality at Jukehi near Katni, and dolomite at Panposh, were secured.

The initial stages of locating the necessary raw materials and securing rights to work them were now completed, and the explorers set their attention to the selection of a suitable spot for their assembly, which might be centrally placed in regard to the various supplies. Eventually a site at Sakchi near Kalimati station, eighty miles east of Sini Junction, was selected early in 1908. The spot is 150 miles west of Calcutta, 40 miles from the Gurumaishini iron ore mines, and 115 miles from the Jherria coalfield, and the works are bounded on the north by the Subnareka river, and the west by Khorkai river. The former had never been known to run dry in the hottest summers, and thus afforded ample water-supply, a most necessary feature in a steelworks. On the south the estate is bounded by the Bengal-Nagpur railway. The Indian Railway Board, as a mark of sympathy and goodwill, placed an order for ten years' annual supply of 20,000 tons of steel rails, the conditions being that the rails must comply with Government specification, and the price be no more than similar goods delivered c.i.f. Indian ports. They further constructed forty miles of line connecting Kalimati with the Gurumaishini ore mines, and made special valuable concessions in freight rates dependent on certain ton mileages covered per year. The plant as originally erected consisted of two blast-furnaces, designed for 175 tons per day, or 120,000 tons per annum; four Siemens-Martin open-hearth furnaces, with an output of 85,000 tons ingots per annum, blooming-mill, rail and beam mill, two bar mills, 180 Coppee non-recovery coke ovens, the total output of finished steel being 72,000 tons per annum. Machinery began to arrive in 1910, and the coke ovens were fired for the first time on October 12, 1911. On November 2, 1911, the first or "A" blast furnace was blown in, and "B" furnace on September 25, 1912. Early in the same year the steelworks began operation, and the first piece of ingot steel was rolled in the blooming-mill on February 16, 1912, while a month later the first rails were produced, being followed in October by the bar mills producing flats, squares, and rounds. Many difficulties were experienced and surmounted, as one department after another was started. This being the first time that the manufacture of steel under modern conditions had been undertaken in India, absence of previous experience of working under tropical conditions, and employment of entirely unaccustomed labour were excuse for failure to attain results achievable under Western conditions. In the initial stage there was much alteration, pulling down, and reconstruction. Steel output fell far short of standard, and transient labour imported from Germany handicapped the efforts of the management. Perseverance on the part of the firm, the staff, and their expert advisers, eventually triumphed, and the preliminary period was educational for the works and enabled the management gradually to reduce the percentage of European or American employees and substitute Indian labour. In many instances Indian workmen have shown themselves possessed of extraordinary skill and manual dexterity. When most of the difficulties had been overcome, the war broke out, and added a new source of apprehension to the management. The open-hearth department was being operated by a German crew, and it was necessary to make immediate arrangements for the substitution of an English crew, the Germans being interned at Ahmednagar. Mr. Perin, who had now taken charge in an advisory capacity, made efforts to reduce costs of production, and essential additions were made. The 180 Coppee coke ovens proving insufficient, fifty Koppers by-product ovens were ordered in 1914, and began to turn out coke in 1916, the by-product plant being started up shortly after. Sulphate of ammonia and tar were now added to the sales list of the company, and materially reduced the manufacturing cost of coke, and consequently pig-iron. The blast-furnaces designed for 175 tons per day each, are now turning out 280 tons as a result of Mr. Perin's alterations, and the receipt of new and more powerful blowing engines is expected to reduce coke consumption to well below one ton per ton of pig-iron.

An interesting experiment is shortly to be tried in Mysore. The Government of that State has decided to erect a charcoal blast-furnace, and have appointed Mr. Perin as their consulting engineer. He has placed orders for the equipment in America, and the undertaking is to be managed by the Tata Iron and Steel Company. It is proposed to fell and transport timber from the vast forests of Kadur and Shimoga, and convert it into charcoal at Benkipur. Iron ore will be mined at a distance of twenty-five miles, and a high-grade charcoal iron produced. In 1916 a world shortage of ferro-manganese was experienced, and great difficulty was found in providing the Sakchi furnaces from England. One blast-furnace was accordingly put on to this manufacture, and 3,000 tons were made, of slightly lower manganese content than is used here, but valuable for their works purposes, and over 1,000 tons has been sold to America. Silica and magnesite bricks originally imported from Europe are being made locally from indigenous materials, and the latest results show that the company will soon be independent of outside sources of these supplies. During the second year of the war all the steel output of the works was at the disposal of the Government, shell steel was being supplied to Indian munition works, and rails to Mesopotamia. The demand for more and more steel had determined the firm to enlarge the manufacturing capacity, and the consulting engineer was instructed to draw up a report on a generous scale for extentions. Hitherto pig-iron, steel rails up to 100 lb. per yard, joists, angles, channels, squares, and rounds, comprised the total diversity of output. The report on extensions was submitted in March 1916, and acted upon in the following autumn. War conditions made it difficult to purchase complete plant, and it was therefore decided to procure machine tools and equip a large machine-tool shop, and manufacture the bulk of the new plant at Sakchi. The extensions will comprise two blast-furnaces of the latest American design, having an output of 600 tons each per day; a blast-furnace has also been bought second-hand, and will shortly be re-erected at Sakchi, for the manufacture of ferro-manganese. So large a tonnage of pig-iron will require ample coke, and 200 Wilputte coke ovens, each of 13 tons capacity and having a coking time of eighteen hours, are being erected. It has been decided to add a blooming mill, a Morgan continuous sheet, bar, and billet mill, a Morgan continuous merchant mill, a plate mill, a wire-rod mill, a sheet mill, a second rail mill, a pig-casting machine, steel sleeper presses, a cast-iron pipe foundry, and a bolt, nut, and rivet works. The four Siemens-Martin 40 ton open-hearth furnaces have been enlarged to 50 ton, and two new 50 ton open-hearth furnaces have been added during 1917, enabling an output of 18,000 tons per month to be maintained. These will be further supplemented by a duplex process of steel manufacture, which materially reduces the time of conversion. Three 6 ton electric furnaces will produce refined steel suitable for springs, tool steel, etc., or may be devoted, should occasion demand, to making ferro alloys.

PLATINUM OCCURRENCES IN AUSTRALIA.

The future difficulty of obtaining platinum from Russia has led consumers to look for possible supplies elsewhere. Mr. B. Dunstan, the Queensland Government Geologist, in preparing a general statement relating to the production and uses of the metal, gives some particulars of occurrences in Australia and of likely localities for prospecting.

Little attention has been given to the occurrence of platinum in Queensland, and notwithstanding the fact that conditions are favourable for its presence in many localities, few discoveries of the metal have been made. For a long time it has been known to occur in the beach sands between Southport and Currumbin on the south coast, and also on Cooppooroo and Wairamba creeks on the Russell goldfield, near Innisfail (Geraldton). It has likewise been found in the alluvial deposits of Brickfield Gully and in the Lady Mary and Alma reefs on the Gympie goldfield. To these another unrecorded locality has to be added, as it has been learned that alluvial platinum was found many years ago at the head of the Don river, in Central Queensland, at a position about 30 miles south from Mount Morgan and about 20 miles above the junction of this river with the Dee river. Within other states of the Commonwealth the metal has been found in New South Wales, Victoria, South Australia, and Tasmania. In New South Wales the deposits are situated principally at Fifield and Platina, and also about the Tweed and Richmond rivers, on the north coast, while in Victoria the most important occurrence is in the Walhalla copper mine.

Mr. Dunstan gives some details of the chief occurrences in Australia and their geological characteristics.

At Gympie, the Lucknow and Alma gold-bearing reefs many years ago yielded a few platinum specimens, but no attention was then given to the occurrence.

TABLE I.—VALUES IN BEACH-SAND CONCENTRATES, NEW SOUTH WALES.

Locality	Gold Per Ton			Platinum Per Ton			Osmiridium Per Ton			Other Constituents
	oz.	dwt.	gr.	oz.	dwt	gr.	oz.	dwt.	gr.	
Evans Head	2	19	3	0	18	17	0	0	15	5·12% of tin (met.)
Evans Head	15	1	12	2	18	3	0	17	7	28·52% tin (met.)
Richmond River	0	9	11	129	9	16	58	0	7	5 oz. iridium per ton
Ballina	2	19	12	428	9	4	161	13	20	26 oz 16 dwt. ir. per ton and 2 oz. 16 dwt. plat. metals

TABLE II.—VALUE IN BEACH SANDS, CURRUMBIN, QUEENSLAND.

Locality	Tin	Gold Per Ton			Silver Per Ton			Platinum Per Ton	Thickness of Bed
	%	oz.	dwt.	gr.	oz.	dwt.	gr.		
Flat Rock (½ mile S.E. of)	0·18	0	0	12	0	4	2	trace	18 in.
Flat Rock (1 mile S.E. of)	0·17	0	1	19	0	3	22	trace	4 ft.
Flat Rock (1½ miles S.E. of)	trace	0	1	0	0	4	10	trace	6 in.
Coolangatta Cr. (50 chs. N.W. of)	0·64	0	0	17	0	4	20	trace	6 in.
Flat Rock Cr. (mouth of)	0·26	0	1	7	0	7	2	trace	4 ft
Flat Rock (2½ chs. S. of)	trace	0	0	5	0	3	22	trace	3 ft.
Flat Rock (2½ chs. S. of)	0·12	trace			0	3	12	trace	18 in.
Flat Rock (3 chs. S.E. of)	trace	0	0	5	0	4	22	trace	4 ft.
Concentrates*	8·30	1	16	8	0	12	19	trace	
Concentrates †	1·69	0	7	5	0	5	5	trace	
Concentrates §	0·10	0	0	22	0	5	3	trace	

* Results of 2 weeks' sluicing, 191 lb. † One week's work, 3 cwt. of high-grade concentrate from 20 tons of sand.
§ Results of 20 tons of sand, 7 cwt. of low-grade concentrate.

The metal occurred in a quartz lode with native gold and arsenopyrite, the associated rocks being purple and black slates alternating with volcanic tuffs and conglomerates. In the vicinity of these reefs the platinum has also been found in rich gold-bearing alluvial deposits, and one specimen is said to have weighed several pennyweights.

In New Zealand platinum has been found under a variety of conditions, among which it is recorded as occurring on the Thames river in a region of serpentine and diorite in quartz lodes, and also at Westland in similar country in a pyritic lode. In Tasmania platiniferous deposits have not yet been proved to exist, although osmiridium is an important product. It occurs in serpentine on the Bald Hills about the Savage river in the north-west quadrant of the State. In Victoria a noted occurrence of platinum is that in the Walhalla copper mine, where it is associated with gold, silver, and copper pyrite in a lode formation in hornblende diorite.

At Fifield and Platina, 1½ mile apart, and 54 miles north-west of Parkes in New South Wales, there is an occurrence of alluvial platinum which is the most important deposit of its kind in the Commonwealth. The rocks about the lead, which is one and the same in the two localities, are mostly slates, and the platinum in association with osmiridium and gold is in a gravelly wash, but apparently there is nothing to indicate the character of the rocks from which these minerals have been shed. One specimen, however, has been found which contains both native gold and native platinum so associated that they must have had a common matrix, and this rather suggests their source to have been outside a serpentine area.

In New South Wales platinum-bearing lodes have been recognized at Mulga Springs Creek, situated near Broken Hill, the metal being in a copper-nickel gossan closely associated with gabbro and decomposed gneisses and schists. It has been considered to bear some resemblance to the Sudbury deposits.

Beach sand deposits containing platinum are common on the north-eastern coast of New South Wales and on the south-eastern coast of Queensland. At Ballina, close to the mouth of the Richmond river, at Evan's Head further south, and also at Currumbin, near the mouth of the Tweed river further north, deposits of black sand accumulate along the beaches during stormy weather, which are covered by other sand deposits when weather conditions become normal. All these black sands contain gold, tin, monazite, platinum, and osmiridium in very fine grains and in association with topaz, zircon, garnet, tourmaline, ilmenite, magnetite, chromite, and sapphire. The sources of these minerals are problematical, but the platinum and osmiridium appear to have been derived from the serpentine area which forms, in part, the western edge of the Clarence Coal Measures, and which are only to be observed now as fragmentary outcrops, while the gold, tin, and monazite might have had their origin in the granite and other rocks of the New England Tableland. Possibly in former times the platinum and other minerals, each from their individual source, were accumulated in the sediment forming the Clarence Series of rocks, and which natural agencies are now redistributing in the coastal sands. Along this coast the disposition of sand is northerly from the rivers bringing the material down from the high lands, and this suggests the idea that the sources of the minerals are always south of the beach deposits in which they happen to occur. Some of the Currumbin sands, indeed, have been found to contain chromite, which rather indicates the serpentine to be the source of some of the minerals contained in them. At Ballina and Evan's Head the platinum is the predominating mineral in the sands, with gold only in small quantities, while at Currumbin, further north, and further from its source, the platinum is only in traces, with the gold in greater quantities.

At the deposit at Mulga Hill Creek, near Broken Hill, New South Wales, mentioned above, the platinum values in the lode vary from a trace to 16 dwt. per ton, a felspathic ochre containing about 1½ oz., and a ferruginous claystone about 6½ dwt. per ton. Picked specimens of the ore were also found to contain from less than 1% up to 10% of copper, from 0·35 to 4·33% of nickel, and from traces up to 0·27% of cobalt. At Fifield the alluvial deposits have yielded 6 dwt. 2 gr. of platinum and 1 dwt. 23 gr. of gold per ton, but there does not appear to be much promise of a continuation of these returns on account of the limited extent of the wash-dirt in the lead. The ore of the

Walhalla Copper Mine, in Victoria, contains from 2 dwt. 18 gr. to 7 dwt. 20 gr. of platinum per ton, some bulk samples showing from 2 to 7 dwt. of platinum, with gold, silver, and copper also present. The Sudbury nickel ore, which is said to be somewhat similar in character to the Walhalla copper ore, contains 0·17 to 0·50 oz. of platinum per ton, although only a small quantity of the metal so far has been recovered, the annual yield being 100 oz. or less.

The beach sands of the New South Wales coast vary considerably in their platinum contents, and no definite yield per ton appears to be known, although the value of the concentrates has been determined. The yields of gold, platinum, osmiridium, &c., from concentrates obtained at Ballina, Richmond River, and Evan's Head are given in Table I, the results obtained, however, being only from small parcels and not sufficiently general to give any data on which to base a commercial proposition.

At Currumbin Beach, near Point Danger, some mining operations have indicated the beach sands to be of small value, and it is evident that the working of the sands in this locality, to be successful, must be conducted with much more efficient labour-saving appliances than have been employed. The yields occasionally have shown that the sands contain high values in tin, gold, silver, platinum, and monazite, that is, from 8s. to 12s. per ton; but the general averages must be put down at about as many pence per ton, and even then the platinum values are exceedingly small in comparison with those of the other constituents. The values obtained from a number of tests are given in Table II.

An experiment tried with a sample of Currumbin sand showed the black grains to be much finer than the white silicious portion, and that by passing the sand over an 80 mesh sieve a fine black concentrate was obtained which only contained about 30% of white sand. The black sand was also found to be highly magnetic and a high percentage of the fine-screened concentrate could be removed by this means, the operations of screening and magnetic separation together yielding a product which probably would be no more than 5% of the original bulk. Such fabrics as cocoanut matting and carpet in the bottom of the sluice-boxes usually employed in beach mining are troublesome to keep in order, and to be effective require careful attention, so that in the utilization of metal screens and magnetic separators with other labour-saving mechanical arrangements a possibility exists of effectively handling the black sands on this part of the coast. Capital appears to have been spent in attempting the recovery of the metals on the New South Wales coast, but opinions differ as to whether the cause of the failures has been through the poorness of the sands, mechanical difficulties, or bad management.

Platinum refining in Australia has not yet been undertaken, but this would have eventuated were it not for the war. All preparations have been made to do so at the metallurgical works at Cockle Creek, in New South Wales, where it is proposed later to refine both platinum scrap and crude metal.

In summing up the evidence, Mr. Dunstan states that so far as Queensland is concerned, there is nothing tangible on which to base an opinion on the prospects of obtaining platinum in payable quantities in either lode or alluvial deposits, but there is a lot to be done in investigating areas where possible supplies exist. Nothing whatever has been done to determine its absence or presence in the alluvial deposits about the serpentine areas, and before any decision can be arrived at the deposits about Kilkivan, Mundubbera, Cawarral, Canoona, Bowen, and other places will have to be examined, more particularly where the serpentines have been disturbed by intrusive dyke masses. The presence of wollastonite in association with copper at the Mount Hector mine, in the Gladstone district, is also worthy of attention, as platinum has been found in this mineral in other places under the conditions that prevail in that locality. The coastal areas also should not be neglected, and some consideration given to the concentration of the black sand by some system of sieving and magnetic treatment.

ASBESTOS IN SOUTH AFRICA.

The *South African Journal of Industries* for November contains a paper by Dr. Percy A. Wagner on Asbestos: its Commercial Uses and Sources of Supply. Canada is the leading producer, followed by Russia, South Africa, the United States, and Cyprus. We extract here the information given by Dr. Wagner relating to South African deposits.

There are three chief minerals yielding asbestos: (*1*) serpentine, which occurs in two fibrous forms, chrysotile and picrolite, (*2*) iron-amphibole, and (*3*) crocidolite. Other minerals are anthophyllite, tremolite, and actinolite.

Chrysotile asbestos is by far the most important, about 90% of the asbestos used at the present time being of this variety. Iron-amphibole and crocidolite, of the production of which South Africa has virtually a monopoly, rank respectively second and third in importance. In view of the great extent of the South African deposits of these minerals they are undoubtedly destined to play an important rôle in the asbestos industry. There is no probability, however, of either of them ever rivalling chrysotile asbestos, for, quite apart from the fact that the available supplies of the latter mineral are practically unlimited, there are a number of uses to which it is specially suited and for which the other varieties of asbestos do not form satisfactory substitutes.

Chrysotile asbestos always commands a higher price than the other varieties owing to its exceptional spinning qualities. The best grades of chrysotile asbestos realize up to £75 per ton, and the best grades of crocidolite asbestos up to £65 per ton. As regards the physical properties of the different minerals, anthophyllite, tremolite, actinolite, and chrysotile are all capable of withstanding exposure to very high temperatures, but whereas anthophyllite, tremolite, and actinolite asbestos are, generally speaking, not sufficiently flexible to be well adapted to spinning and weaving and are of deficient strength, chrysotile asbestos is by reason of its silkiness and flexibility eminently suited to textile purposes. Crocidolite, owing presumably to its high sodium content, is easily fusible in an ordinary gas flame, swelling to a black magnetic glass and colouring the flame yellow. On the other hand it possesses greater tensile strength, and is more elastic than chrysotile, and its superiority over that mineral as an insulating material with regard to heat is well established. Similar superiority is also claimed for electrical insulating purposes. Its chief advantage over chrysotile asbestos lies, however, in the fact that it offers far greater resistance to the action of acids, chemical solutions, and sea-water. Sea-water and moist sea-air slowly decompose ordinary chrysotile abestos, whereas the crocidolite variety is practically unaffected by them. With regard to the physical properties of iron-amphibole asbestos very little is known. Judging by its chemical composition it should be markedly superior to crocidolite in fire-resisting power and to chrysotile asbestos in its resistance to acids and sea-water. Its tensile strength appears to be of a high order.

South Africa has vast resources of asbestos and produces a greater variety of commercial fibre than any other country. The asbestos industry, established in 1893, has of recent years made astonishing progress, as may be judged by the fact that whereas the 1913 output was worth only about £30,000, that for 1916 was valued at £182,129, and that for the first eight months of 1917 at £203,179. Production during the past two or three months has been at the rate of about 20,000 tons per annum.

The most important South African deposits of chrysotile asbestos are those of Southern Rhodesia, which at the present time are producing over 900 tons per month of excellent quality. The Rhodesian fibre is the only class of chrysotile asbestos that has been able to compete successfully with the best grades of Canadian crude. The mineral was first discovered in the Mashaba mountains, about 26 miles west of Victoria, and the Victoria district until quite recently ranked as the premier producer. Within the last two years, however, extensive and rich deposits have been opened up in the Belingwe district, and the output of these is at the present time slightly in excess of that of the Victoria district mines. Asbestos is also being worked in the Gwelo district, and finds have recently been reported from the Lomagundi district. The deposits are all in belts of ancient serpentine, and as these are extensive and as yet but little known many important occurrences no doubt still await discovery. The asbestos is of the cross-fibre variety, and occurs under the same conditions as the Canadian, in irregular narrow veins ramifying in every direction through the enclosing serpentine. The fibre ranges in colour from pale green to pale greenish-white, that of the Belingwe district being somewhat longer and also more silky than that of the Victoria district. The fibre is readily separated from the matrix by cobbing, crushing, and screening. No attempt is made to save the shorter grades of fibre.

Of a different character are the occurrences of chrysotile asbestos in the Carolina district of the Transvaal. They are situated about fifteen miles east of Carolina in a tract of rugged mountainous country belonging topographically to the Drakensberg. The asbestos occurs in a bed of serpentinized dolomite in the uppermost division of the dolomite formation immediately above a persistent intrusive sheet of diabase with which the deposits are believed to be genetically connected. The asbestos-bearing dolomite, a massively bedded rock of delicate pale greenish-white colour, is said to be traceable at the surface for a distance of twenty miles, but only carries workable deposits of fibre over part of this distance. The asbestos is found in thin seams in the lower portion of the stratum, the seams running parallel with the bedding planes of the dolomite, which dips to the north-east at an angle of 15°. They sometimes occur singly, but usually two or three seams run parallel to one another and separated by a variable thickness of the country rock. The individual seams range in thickness from a fraction of an inch to 8 in., thinning and thickening with the utmost irregularity. They are rarely continuous over any considerable distance and frequently die out within a few feet. The seams, as a rule, consist wholly of closely compacted parallel fibres extending from wall to wall without break or fault, the fibres being arranged at right angles to the bedding planes. The normal fibre is of excellent quality as regards length, flexibility, and tensile strength, and commands high prices, the best grades realizing as much as £70 per ton. The asbestos zone has been opened up by means of adits and tunnels. The seams become progressively thinner as they are followed inward and appear eventually to pinch out altogether, inasmuch as no asbestos is found at the head of any of the deep valleys running into the hills.

An occurrence of chrysotile asbestos is being opened up on the farm Dalton, close to Kaapmuiden, in the Barberton district. Whether it is workable or not is not as yet known. Chrysotile asbestos of good quality was reported some months ago to have been discovered in serpentine, associated with the old granite, to the north of Krugersdorp. No precise information regarding the nature and extent of the deposits is available. A deposit of chrysotile asbestos on which a good deal of work has at different times been done is situated at Isitilo in Zululand near Middle Drift on the Tugela river. Chrysotile asbestos in veins up to ¾ in. in width is also found near Eshowe, but the occurrence does not appear to be worthy of exploitation.

As regards tremolite-asbestos a deposit is being worked near Pomeroy on the Maceheko river in Zululand. The fibre is soft and silky to the touch but of very low tensile strength, and is employed principally for covering boilers and steampipes. It appears to be admirably adapted for making asbestos millboard and for use as a filtering medium for acids and corrosive liquids.

We pass now to the consideration of occurrences of crocidolite-asbestos. Asbestiform crocidolite of a peculiar lavender blue colour, commonly known as blue asbestos, has been mined in Griqualand West for twenty years. The mineral has a wide distribution in the lower portion of the Pretoria series as developed in the Asbestos Mountains and their northern continuation, the Kuruman-Honingvlei range, the deposits extending from a point thirty miles south of the Orange River to the Bechuanaland border, a distance of fully 250 miles. The width of the asbestos belt ranges from four to twenty miles, and, as regards actual areal extent, it undoubtedly constitutes the greatest asbestos-bearing area in the world. The asbestos occurs in thin layers and attenuated lenses conformably interbedded with the hard banded jaspers and ironstones of the Pretoria series. The fibre, as a rule, is arranged at right angles or inclined at a high angle to the bedding planes. It varies in length from a maximum of about 3 in. to almost microscopic dimensions. Over a great part of the asbestos country the strata are practically horizontal and the same bed will often appear on successive hills. At Koegas, on the Orange River, however, and also at Westerburg, the beds have been folded, the dip being almost vertical. In other localities the strata are contorted owing, it is presumed, to the removal through solution of the underlying dolomite. Where this is the case the asbestos layers are sometimes seen to thicken in the arches and troughs, and to disappear altogether in the connecting limbs. The fibre from different parts of the asbestos area varies in character. That of the Kuruman district has a slightly lower specific gravity than that of Koegas and the southern districts, and is also softer and more silky when carded. These differences correspond no doubt with slight differences in chemical composition.

The mining of the asbestos, whether by open-cut or underground methods, is simple and comparatively inexpensive, though the following up of the thin and impersistent seams necessarily entails a good deal of dead work. The fibre is readily separated from the enclosing shale and jasper by cobbing with light hammers, and this is the principal method of dressing resorted to. At Koegas a plant consisting of a pair of corrugated rolls arranged to run at different speeds and some sieving trommels has been installed, but all that is attempted is a rough cleaning of the short and inferior fibre. The principal concern operating in Griqualand West is the Cape Asbestos Company, which, in addition to being the most important producer, handles the greater part of the output of the smaller companies and syndicates. The company was formed in 1893 and owns 67,000 acres of proved asbestos-bearing ground. At the present time it produces about 100 tons of fibre per month, and buys approximately the same quantity. The company is also by far the largest manufacturer of blue asbestos goods. The company had a very hard fight to win for blue asbestos the recognition to which it is so richly entitled, and has only of recent years reached the dividend-earning stage.

As regards occurrences of iron-amphibole asbestos an asbestos field of exceptional promise has been opened up during the past two years in the northern portion of the Lydenburg district of the Transvaal, the asbestos occurring in bedded veins in ferruginous shales belonging to the basal portion of the Pretoria series, at a slightly lower horizon than the Griqualand West deposits. The deposits have not as yet been accurately delimited, but appear to be of very great extent. The mineral was first discovered on the Farm Penge, situated about 50 miles north of Lydenburg. At the present time operations are confined to Penge and the adjoining farm Streatham. These farms are situated in the valley of the Olifant's river, where the latter breaks through the Drakensberg. The area is mountainous and rugged and very inaccessible. The distance by road to Lydenburg, the nearest point on the railway, was originally 75 miles, but this has been reduced to 65 miles by the construction of a more direct road. The asbestos is found in long irregular lenses up to 12 in. in thickness that overlap in such a manner as to form practically continuous layers extending over hundreds of yards. The lenses conform to the stratification of the enclosing rocks.

The pale greenish fibre from the lower workings on Penge is at present being shipped in considerable quantities to Japan and the United States. It appears by reason of its length and great tensile strength to be admirably adapted for the manufacture of asbestos rope and textiles, and as no other field is capable of producing fibre of this length in such large quantities there can be no question that the mineral is going to play a very important rôle in the asbestos manufacturing industry. The precise mineralogical composition of the fibre has not as yet been determined. It is undoubtedly amphibole asbestos, apparently monoclinic with a very small angle of extinction. It differs from tremolite and actinolite in containing up to 37% of ferrous oxide, from crocidolite in being apparently quite free from soda, and from all these minerals in containing up to 9·3% of alumina. The various analyses so far made are difficult to reconcile.

PRESERVATION OF MINE TIMBERS.

In our issue of January, 1917, we gave a full abstract of a paper on the prevention of decay in mine timbers read by J. Mitchell before the Midland Institute. This subject has recently engaged the attention of the Department of Scientific and Industrial Research, the object being to devise means to conserve the limited supply of mine timbers available under war conditions. The Department has issued a report on the subject written by Professor Percy Groom. This report we reproduce herewith.

The decay or disintegration of timbers is, for the most part, caused by various fungi which permeate and devour the wood, and often clothe its surface with a fluffy or cottony material known as spawn. This spawn, usually white but sometimes coloured, can rapidly grow over the timber, walls, or floor, and may even be broken off and transferred elsewhere, and thus reach and infect sound wood. These wood-destroying fungi also produce fructifications, which emit countless microscopic germs, or spores, which, conveyed through the air, may alight on, and attack, pit-wood. Two means of preventing loss through the decay of wood are possible: preventive and remedial measures. Thorough preventive measures are largely impracticable at present owing to difficulties as regards machinery, materials, and skilled labour. On the other hand, remedial measures may be undertaken at once; and it is the main object of Professor Groom's report to point out what they are, and how they should be employed.

Remedial measures are designed to decrease the amount of infection, so that the life of pit-timber will be lengthened on the average, and a corresponding saving be thereby accomplished. Growth of the spawn over the surface of the timber, walls, or floor to sound wood is one means of rapid spread of infection, and is aided by the transference of the spawn by other agencies such as wind-currents, on men's clothes, packing of rejected pit-wood close to sound wood, &c. The checking of this superficial growth cannot do more than diminish the rate of decay of the timber, because the wood-attacking fungi grow also inside the timber: but inasmuch as the fungus grows more rapidly outside than inside the wood, the rate of destruction of pit-wood will be decreased by killing spawn on the surface. Infection will likewise be decreased by the removal and destruction of the germ-producing fructifications that emerge from the wood.

In order to accomplish these ends, it is necessary, first, that colliery timber-men should be taught to recognize the spawn and fructifications. Afterward a scheme of inspection and treatment should be instituted. Starting from the intake, and travelling with the air currents to the return ways, the timber should be periodically inspected for fungus-material on the timber. Where fungus occurs, the accessible pit-wood should be treated as follows: (*a*) The apparatus required would be a pail, some cloths, a cloth or cotton swab, a strong knife, and an antiseptic solution properly made up. (*b*) The following antiseptic substances are suitable and are arranged in order of preference: (*1*) Creosote and its various derivatives, (*2*) zinc chloride, (*3*) copper sulphate, which should not be used where the mine-water is rich in iron. (*c*) Every fructification (shaped like a cushion, bracket, or mushroom) should be removed by cutting away the portion of wood to which it is attached. These should be placed in the pail, carried to the surface, and burnt in the boiler fires. All waste timber lying in the roadways and recesses should also be brought to the surface and burnt at once. Instant burning is important, as a good deal of infection of sound timber takes place during storage above ground, because decaying wood is allowed to lie about among it, and so the infection is spread to timber originally sound. The result of this would be to stop much of the infection that is caused by microscopic germs or spores. (*d*) At the same time or subsequently, the spawn on the surface of the pit-timber would be dealt with as follows. Each man engaged would carry a swab, the cloths and a pail three-quarters full of the antiseptic solution chosen. All the accessible wood, including props, balks, crown-trees, bars, and collars, would be washed with the solution, and the spawn removed. The solution and cloths would require to be renewed from time to time. When possible, loose bark should be removed and the bare wood washed over with the solution. This treatment would serve both to check the growth of spawn over the surface and to prevent its transference from one part of the mine to another, and thus would hinder new infections. But a certain amount of the antiseptic solution would be absorbed by the wood, and on drying would leave on or near the surface a thin film of antiseptic substance which would check the growth of any germs that might alight on the wood. A great deal will depend on the thoroughness with which these operations are carried out. When once begun the treatment should be systematically and regularly pursued, as these wood-attacking fungi grow rapidly, and temporary neglect may undo the work of months. The mine-timber should therefore be examined at least once a month. The consequence of the treatment will be a steady improvement in the condition of the mine-timber from the very commencement. It will, however, be evident that one limitation to the beneficial effects will be due to the inaccessibility of decaying wood packed under the roof above the balks, crown-trees, bars, or collars.

The methods detailed above constitute a direct attack on the wood-destroying fungi, and are designed to reduce the loss occasioned by decay in mines that are already infected. An entirely different method of dealing with the problem is a defensive one, and involves the protection of the wood by rendering it immune to infection by fungi. Wood can be protected more or less perfectly from decay-inducing fungi by coating or impregnating it with an antiseptic substance. The degree of protection thus afforded depends upon the substance used and upon the depth to which it penetrates the wood. Mere superficial coatings are less efficient than injections to some depth within the surface; while perfect protection is ensured solely by impregnating the wood throughout. Various substances are very unequal in their power of conferring upon wood resistance to fungal attack. In some coal-pits mere soaking with mine-water lengthens the life of the wood; at the opposite extreme of efficiency is creosote, which confers indefinitely long durability upon wood. The exact treatment to be adopted will depend therefore on the circumstances of the case and particularly upon the time during which the wood is required to remain sufficiently sound to be of service. Superficial washes are applied by means of a brush; and when this or any other method of application of the antiseptic is adopted, bark must be removed from the timber before treatment. Somewhat deeper penetration is ensured by soaking the wood for a longer or shorter time in the heated antiseptic solution. For this purpose, timbers, before being taken down into the pit, should be soaked for at least 15 minutes in a tank of 10% zinc chloride at a temperature of 130° F., or in creosote as hot as it can conveniently be used. When the props are put in position in the ways, their tops where bruised by the hammer should be painted over with the preservative, as infection often starts at these spots. For deeper penetration, more prolonged soaking is essential, and the deepest penetration is ultimately secured with greatest economy by pneumatic pressure and the use of a creosoting plant if large quantities of wood require treatment. Creosote and its derivatives, or zinc chloride, represent the most economic and efficient antiseptics for use in mines. But a number of salts confer feebler resistance, and may be used where the wood has to last only a relatively short time before being removed; among these are common salt, magnesium sulphate, certain mine-waters, copper sulphate (not to be used where the mine-water is rich in iron); iron sulphate, sometimes recommended, should not be used. This policy of replacing timber in mines by wood rendered more or less antiseptic should be followed in all cases. When carried out in the most thorough manner, it gradually brings the pit into a completely sanitary condition. For instance, thoroughly creosoted pit props that when unprotected collapse from decay in a few weeks will last for many years. Discarded creosoted railway sleepers similarly will serve for indefinite periods as sound cross-bars. The precise method of dealing with mines in order to eradicate or decrease decay of timber will vary somewhat in detail in different cases. In regard to this, advice may be obtained from the Department of Scientific and Industrial Research. The significance of wood-attacking fungi, and possibly certain bacteria, is not confined to their destruction of timber, for during their growth they may produce black damp, and the amount of this gas that they produce is directly proportional to their abundance and vigour.

Accuracy in Chemical Balances.—In our last two issues we have quoted Mr. Bertram Blount's call on the makers of chemical balances to produce a balance that will preserve its reliability for over three months without testing or adjustment. Mr. Blount has explained that such a balance is required for investigations involving the non-interference with the charges in the pans during the whole period. He has since, in collaboration with Mr. W. H. Woodcock, contributed a paper to the proceedings of the Chemical Society describing the cases specially designed for the purposes of protecting such balances.

He showed in his previous paper that a balance guaranteed to be accurate to 0·1 milligramme with a load of 200 grammes varied ½ to 1½ milligramme in tests over a period of four months. The main object of Mr. Blount's research made it necessary to weigh accurately, in any gas inert toward the materials composing the balance and the matter to be weighed, or in a vacuum, with, approximately, the same ease as ordinary chemical and physical weighings are performed in balance cases of the usual construction. Little work of the kind has been done in this matter, although various vacuum balance cases have been made. The authors wished to improve on what had been done, and with the aid of Messrs. Casella designed a balance case in which the ordinary wooden balance case was reproduced in every essential, but in gun-metal. The top is of plate-glass, about 1·9 cm. thick, sufficient to withstand atmospheric pressure when the case is exhausted. The door, which is of plate-glass, in a gun-metal frame, is carried on a loose hinge, and can be brought up square with the case, and tightly closed by means of thumb screws. All surfaces are scraped as for a surface plate. The glass top carries a pressure of 750 kilogrammes, and the front about 1,000 kilos. The mode of raising and lowering the beam is that used for the ordinary analytical balance, but as the balance case must be air-tight the cam-shaft passes through a stuffing-box. In like manner the rider rod passes through a stuffing-box, and as it was found impossible to get this tight with the ordinary movements of a rider rod, an arrangement by which the rider could be moved by a screw motion was adopted. This first test showed that the case was not tight. It was naturally supposed that this was due to inaccuracy of mechanical fitting, and various methods of making the surfaces come physically together were tried. The ordinary mechanical mode of making a tight joint between two metal surfaces is to insert a ring or washer of a softer metal. Lead appeared to be unsuitable, as it might be corroded, so gold was tried as a similar plastic metal. Pure gold is extremely difficult to handle, and many hours were spent in fitting the gold washers accurately to the gun-metal case. This mode of making the case tight was a failure. Re-machining and scraping of the metal surfaces caused little improvement. Ultimately it was found that the metal was so porous that to maintain a vacuum within it was impracticable. Accordingly, the gun-metal case was tinned by immersion in a bath of molten tin, but was still porous. It was then enamelled both inside and out, and the leakage was considerably reduced. It is well known that gases find their way through metal under high pressure, but the authors were surprised at the large leakage which occurs with such an alloy, mechanically sound, and with its pores well blocked with tin, at so small a pressure as 1 kilo. per square cm. As mentioned, washers were made of very pure and soft gold, and every effort was tried to construct a case, satisfactory from an engineering point of view. These efforts failed, and the methods of the chemist had to be adopted. The plate-glass top and door, instead of being fitted to a scraped gun-metal surface, were made tight with vacuum grease applied to the same surfaces. The gun-metal cocks, two sets of which were tried, were abandoned in favour of glass. With these improvements the case was fairly satisfactory. Using a Gaede pump, the authors were able to obtain a fair vacuum, with a leakage of somewhat less than 0·01 mm. per hour. It was necessary, for the object in view, to obtain and keep a vacuum of something like 0·001 mm. for an hour without the continued or renewed use of a pump. In short, it was constancy of condition that was sought. With all its defects, the metal vacuum case has certain merits. It is as near an approach to the ordinary analytical balance case, operated in the same way, but capable of being used in any given atmosphere, provided it is not corrosive as has been designed to the best of the authors' knowledge. It can be used as readily with a moderate plenum as with a vacuum. The shifting of both the main weights and the rider can be easily effected with the single necessity of renewing the atmosphere, or vacuum, when the main weights are moved, in which it is intended to work. With modern methods of producing a vacuum or introducing gases from cylinders containing them under pressure, these operations present no difficulty. It may be noted that all such proceedings take time, and any want of constancy of the balance itself will nullify the results of whatever experiment is in hand.

As it seemed impracticable to make a metal case gas-tight, it was decided to use glass wherever possible. A bell jar suggested itself as a suitable case for the balance. The size was a difficulty, and the largest procurable had no side tubulus. Accordingly, one was blown on, and the authors' thanks are due to Messrs. Cossor for accomplishing a difficult piece of work. The bell jar was ground to fit a thick glass plate carried on a gun-metal plate. Through the middle of the two plates was a tube by which the rising and falling of the beam of the balance could be controlled. A Bunge balance, with a 15 cm. beam, was used, as no bell jar could be obtained that would cover a balance with a longer beam. The rider was controlled by a rider rod capable of the same free movement as that of the ordinary analytical balance; eventually the principle of the ordinary glass hypodermic syringe, used without packing, was adopted. The all-glass hypodermic syringe consists of a glass plunger ground to fit the outer tube of the syringe. It is fairly easy to grind conical surfaces to fit, but grinding cylindrical surfaces to a similar accuracy is not so simple and becomes difficult when the material is glass. The difficulty is much enhanced when the length of the cylindrical surfaces is increased. The all-glass hypodermic syringe is a cheap and effective apparatus, but it is only about 5 cm. long, and has only a small opening at one end. It was necessary to make a glass rod, ground to fit a glass tube, with such accuracy as to be almost vacuum tight, having a travel of 25 cm. The outcome of these attempts must be regarded as a success. The balance case can be exhausted to within 0·001 mm., and this vacuum can be kept for over an hour. The rider can be moved with the same ease as that of a balance in an ordinary case. The shifting of the larger weights involves breaking the joint between the bell jar and the plate to which it is ground, a distinct drawback, and a cause of delay. For all that, however, it is an apparatus which may prove useful for this kind of research. All that is necessary now is a balance which will fit into this case and give constant readings for, say, a year, with an accuracy of not less than 1 part in two millions (0·1 milligramme on 200 grammes in each pan), and the authors venture to think that it is not beyond the power of the balance makers to build such an instrument.

The Cost of Water used in Metallurgical Operations.—In the August issue of the *Monthly Journal* of the Chamber of Mines of West Australia, Thomas B. Stevens discusses the influence of the cost of water on the development or application of metallurgical processes.

There are two ways in which the cost of water affects the profits made by the gold-mining industry at Kalgoorlie. In the first place the profit is affected by the cost per 1,000 gallons as compared with the grade of ore treated, the cheaper the water the greater the profit. The second effect is a more intricate one and is brought about by the differential rates which have to be paid according to the use to which the water is put. The result of this discrimination is that the differential rates decrease the profits of the mining companies by binding them down to the use of one process and thus hindering metallurgical progress. The present rates for the sale of water at Kalgoorlie, 7s. per 1,000 gallons for treatment water and 1s. 6d. per 1,000 gallons for sluicing water, were established in 1909, and were particularly applicable to the filter-press process. In filter-press plants all moisture contained in the filter cakes is called "treatment water" and is charged for at the rate of 7s. per 1,000 gallons. The water added to the cake in order to make a pulp thin enough to pump to the tailing area and called "sluicing water" is charged for at 1s. 6d. per 1,000 gallons. The average moisture contained in the cakes may be taken at 13%, or 30 gallons per ton of dry slime costing, at 7s. per 1,000 gallons, 2·52d. It is also usually possible to dispose of a residue pulp containing 40% of water, and to mix filter cakes up to a pulp of this consistency, the addition of 103 gallons of "sluicing water" per ton of dry slime is required, costing 1·85d. per ton; this makes a total theoretical consumption of water for filter-pressing of 133 gallons per ton, costing 4·37d. The same charges are applied to the water used in the vacuum-filter process, but the cakes from the new process contain more moisture than those from the filter-press, carrying on an average 28% or 78 gallons per ton of dry slime, costing 6·55d. The residue pumped away is of the same consistency as before, but on account of the higher percentage of moisture in the cakes the addition of less "sluicing water" is required, the amount being 55 gallons per ton, costing 0·99d., which brings the total theoretical consumption of water for vacuum filtration to 133 gallons per ton, or the same as for filter-pressing, but costing 7·54d., or 3·17d. higher. As far as the saving of gold is concerned the author's experience has been that with well designed plants of ample capacity either type of filter will give the same result. The vacuum-filter requires considerably less labour to operate it than does the filter-press, but as the cost of other items such as power, stores, repairs, etc., are practically the same in both processes, the saving in labour is almost exactly balanced by the increased cost of water. Consequently the development of the vacuum-filter in Kalgoorlie has been retarded, while at other mining centres of West Australia where differential rates for water do not prevail, its use has become almost universal. The present position in Kalgoorlie is that if a mine manager scraps his filter-press plant and installs a vacuum-filter there is a possible saving in working cost of something under one penny per ton, while he pays the Water Supply Department 3d. extra per ton for the privilege of using in his new plant exactly the same amount of water as he did in his old one.

In other parts of the world, the process of counter-current decantation has recently been successfully introduced for separating gold-bearing solution from ore slime. This process is most successful in treating refractory sulphide ores, both in the raw state and when roasted, as it brings the crushed ore in contact with a much larger volume of treatment solution than is possible in a filter process; in fact the ore may be regarded as undergoing several re-treatments. It is already in satisfactory use at two mines in West Australia, both of which are outside Kalgoorlie. The process would be particularly well suited for Kalgoorlie ores, but the price of water absolutely prohibits its introduction. In this process the residue is discharged as a pulp containing about 40% of moisture or of the same consistency as is pumped away from filtration plants, but all of the contained moisture must be regarded as "treatment water" and the 133 gallons per ton required would cost 11·17d. per ton, or 6·8d. per ton more than the same amount of water would cost if used in a filter-press plant, and 3·63d. more than if used on a vacuum filter. Another process which would warrant most careful investigation were it not for the water question, is that of concentration by oil flotation, for in this lies the possibility of greatly reducing the tonnage of material which needs to be put through the cyanide plant. Under present conditions it would cost as much for water as the counter-current decantation process, unless filtration of the worthless residue was resorted to merely to replace "treatment water" with "sluicing water."

Potash from Blast-Furnace Dust. — In our last issue we gave an account of the new process devised by K. M. Chance for recovering potash from the dust of iron blast-furnaces. In the discussion at the adjourned meeting of the Cleveland Institution of Engineers, the society to which Mr. Chance made his communication, E. Bury, of the Skinningrove Ironworks, Lincolnshire, gave some particulars of his experiments with various methods of catching the dust. He disagreed with Mr. Chance's recommendation in favour of wet washing, for his experience was that this method involved a serious loss of fuel; first, cooling down the hot gas coming from the furnaces, from temperatures of 200 to 300° C. to atmospheric temperatures, the sensible heat of the gas thus lost, at a moderate figure, representing 6% by weight of the coke actually consumed in the furnace; second, heavy power consumption for pumping the large quantity of water required, and for the fans necessary to lead the gas through the washing plant. At Skinningrove several dry methods were tested, particularly centrifugal methods and the Halberg-Beth process. The first processes were turned down as indefinite, and the Halberg-Beth process was not found to go far enough in the reclamation of the sensible heat. More recently they investigated the method of cleaning the gas electrostatically, as originally suggested by B. H. Thwaite, and later brought to notice by Sir Oliver Lodge and by F. C. Cottrell. Bell Brothers being equally keen on the possibilities of this method, the two firms decided to make a joint experimental research with Lodge's apparatus, and accordingly a small plant was put down at Skinningrove for dealing with 50,000 to 70,000 cu. ft. per hour, with the blast-furnace gas entirely under working conditions as regards temperature, moisture content, and dust. They experienced no difficulty in reducing the dust content in the gas to 0·2 gramme per cubic metre, which was the standard fixed as being clean enough for stoves and boilers. With the same plant they also succeeded in obtaining dead-clean gas with a decreased flow of gas through the apparatus. These experiments have convinced Bell Brothers and the Skinningrove company that the method is in every way applicable, and they are now going ahead with complete schemes at their respective works. This method of removing the dust from the hot gas involved the use of only a fraction of the power required by wet processes, and, under these circumstances, they had now the means of conserving at the same time their fuel bill, which to them, as metallurgical workers, was of even greater economic post-war value than the potash. On behalf of Sir Oliver Lodge, Bell Brothers, and the Skinningrove company, Mr. Bury claimed that this was the first occasion in this country where this method of removal of blast-furnace dust had been successfully applied. Messrs. Weldon, Hanson, and Bury propose to make these experiments the subject of a joint paper at a later date.

The Potrerillos Copper Deposit.—In the *Engineering and Mining Journal* for January 19, J. E. Harding gives some account of the progress of drilling and other investigation at the Potrerillos copper deposit, in the department of Chanaral, Chile. This property is being developed by the Andes Copper Mining Co., which was organized by the Anaconda company for this purpose, as recorded in our issue of August, 1915. The first ore-body to be tested has been proved to be 1,800 ft. long, 900 ft. wide, and 850 ft. deep, and to contain 32,000,000 tons of ore averaging 1·5% copper. In the vicinity are other deposits which will bring the total to 100,000,000 tons averaging 1·4% copper. The method of mining will be one of low costs. The main haulage tunnel from the millsite terminates under the ore-body at a point approximately 1,000 ft. below the surface. Above this tunnel ore bins will be constructed, leaving 150 ft. of pillar over the tunnel through which the ore will be drawn from the caving level. The method will have a caving level superimposed over a grizzly level. It is intended to undercut the entire ore-body at the caving level by a series of parallel drifts and then to cave the entire ore-body by blasting the pillars between drifts. It is estimated that the total mining cost will approximate 20c. per ton. The geology of the ore-body is simple, it being a late intrusion of quartz porphyry in limestone. The ore developed was formed as the result of secondary enrichment from a primary impregnation, although ore has also been developed in the primary and oxidized as well as secondary zones. Copper minerals are disseminated both in the jointing planes and as inclusions in the rock. Since its intrusion the magma has been extensively faulted and brecciated and the ore has followed certain zones of fault movement which, though widely separated, have formed channels for the circulation of enriching solutions and boundaries for the ore. The ore-bodies do not appear to have been materially faulted by subsequent movements. The metallurgical treatment has not yet been worked out in detail, but as both oxidized and sulphide ores occur, a combination of leaching and flotation will probably be adopted. It has also not yet been definitely decided whether the company will establish the smelter at the millsite or at the coast.

The transport, fuel, and power problems are well in hand. The mine is in the main range of the Andes, east of the port of Chañaral, 90 miles from the coast and at an altitude of 10,500 ft. There are in Chile two main ranges of mountains, of which the lower follows more or less regularly the coast line, and the other the main range of the Andes, or Cordillera. Between the two there is a plain along which has been constructed the main line of the Longitudinal Railroad. This plain extends throughout the country from north to south and is of varying width. Across its area at varying distances, running from the furthermost range of mountains to the seacoast, are numerous ancient river beds, which form natural channels of transportation and drainage from the mountains to the sea. At the sea end of one of the river beds is Chañaral, and at the source the mine of Potrerillos. A railway following up the ancient river bed is now in course of construction to the mine. From the port of Chañaral to the town of Pueblo Hundido the company will use the tracks of the state railroad, and from the latter town a new road is being built to the millsite and thence to the mine. The gauge is 1 m. and 70 lb. rails are used. Mallet-type locomotives will operate from the ocean to the millsite, and beyond this point electric locomotives will be used. The last five miles of railway connecting the mine and mill will be about 75% hard-rock tunnel and will not be in operation for nearly two years. At present practically all the grading to the millsite is completed, steel is being laid, and two steam locomotives are operating over the track as completed. The construction work starts at Barquito Bay from the port of Chañaral. A 22,000 kw. steam turbine electric plant is being installed at this port to transmit power to the mine and mill at 100,000 volts. The port will be equipped with a railroad terminus and docks for steamships. At the other end of the railroad the millsite will be situated. The site selected is in a country of low-rolling sandy hills. A 15,000 ton concentrator, and a model town will be built at the millsite. A supply of water has had to be brought in, as the mine is in an arid desert. For this purpose it has been necessary to go to the permanent snows above, and a pipeline will bring the water from the Ola river. This pipeline will be 36 miles long, and will have an average diameter of 26 in. It will furnish water at the rate of 25 cu. ft. per second. It is laid in a north-easterly direction, over mountains and across gulches. The construction is partly steel and partly wood stave.

The gigantic nature of the Potrerillos enterprise may be gauged by the fact that £5,000,000 will be spent before any copper is produced.

Tin-Dredging in Portugal.—In our issue of January, 1916, T. A. Down gave particulars of tin and tungsten mining in Portugal. He was unable to give particulars of the operations of the Portuguese American Tin Company, in the Gaia Valley, as that company disclosed no information. Some particulars of this company's method of treating the alluvium are given in the *Engineering and Mining Journal* for December 29. The article is written by F. W. Foote and R. S. Ransom, the latter being connected with the James Ore Concentrator Co.

The Portuguese American Tin Co. has been operating the dredge for four years. Controlling stock in the company is held by Californians, who have extensive wine interests in Portugal, and the dredging operations are in the hands of engineers from Oroville. The tin deposit is several hundred metres wide, and 4 kilometres in length. The dredge is constructed of steel. It was designed by H. G. Peake, and was built by Fraser & Chalmers. It has 4 cu. ft. buckets, a treatment capacity of 40 to 50 cu. yd. per hour, and it can dig to a depth of 24 ft. The buckets empty into a large revolving trommel with ½ in. round holes. The oversize is carried to the stern of the dredge by a travelling belt. Any material that does not fall into the trommel is caught in a hopper and passes to a sluice on the lower deck. The undersize from the trommel is split between eight sluices, each 33 cm. wide and 15 cm. deep, which run the full length of the dredge and extend about 4 m. over the stern. These sluices are provided with removable iron riffles, built in sections of seven riffles, 1⅝ in. deep and 2½ in. apart. In ordinary operations only six sluices are in constant use, the two others being in process of cleaning. When a sluice is clean it is "cut in," and another sluice is "cut out" to be cleaned. The material from the sluices is shovelled into a hopper and passes to a second smaller trommel with ¼ in. and 2½ mm. screens. The sized material is then jigged in Harz jigs, and the jig product is carried ashore and washed by the native method, which consists of emptying the material into a deep and slightly inclined launder through which a strong current of water is flowing. The mineral is mixed by hand against the flow of water, and the fines are lost. The authors are of opinion that the method of treatment could be improved by discarding the sluices and replacing them with tables, for the first cost should be small compared to the additional saving that would result. Considerable experience with the native method, as applied to tungsten ores, demonstrates the losses involved by that system of treatment. Another improvement not involving large first cost recommended by the authors would be to screen out all the material through a 1½ mm. impact screen, and sluice only the plus 1½ mm. size, treating the minus 1½ mm. size on tables. The dredge would then be able to handle more material, and the losses in fines would be less and sluicing more efficient. The company does not employ a chemist, so it is impossible to give figures as to the grade of material treated and percentage of recovery. The dredge is electrically operated, power being supplied from a plant owned by the company at Belmonte, 13 km. distant, and transmitted over its own power line to the dredge. The power installation consists of a Babcock & Wilcox horizontal boiler, which supplies steam to a direct-connected turbine generator set made by Fraser & Chalmers. This operates at 3,600 r.p.m., and generates 315 k.v.a. at 6,600 volts and 60 cycles. On shore the current is stepped down to 440 volts, and is used in separate motors as follows: 75 h.p. for the digging ladder, 25 h.p. for the jigs and screens, 85 h.p. for the pumps, and 15 h.p. for the side lines, by means of which the boat is moved. The price of coal has reached a prohibitive figure in Portugal and it is practically impossible to obtain it, so wood is used as fuel at present. Some wood is supplied locally, being brought in by carts and pack trains, and some is shipped in by rail, often coming from as great a distance as 100 kilometres. The finishing plant for producing the final tin concentrate is in a building adjacent to the power plant. Waste gases from the boilers pass through a horizontal chamber, above which is a sheet-iron plate on which the product from the hand washing-plant is dried. The dried product is then fed to a Wetherill magnetic separator to remove ilmenite from the cassiterite. This machine makes a good separation and produces a 75% tin concentrate. The ilmenite is stacked in a waste pile awaiting a possible market. In 1914, the production of tin concentrate was 172 metric tons averaging 68% Sn. In November, 1917, the company was producing about 60 metric tons of 74% concentrate per month. The 1914 production was obtained from the treatment of 169,577 cubic metres of alluvium, and the yield was 1·01 kilogramme per cubic metre.

SHORT NOTICES

Mine Timbers.—A paper was read by F. L. Booth on the strength of pit-props before the meeting of the North of England Institute of Mining and Mechanical Engineers on February 9.

Relining a Shaft. — At the meeting of the Mining Institute of Scotland held on February 9, Henry Rowan read a paper describing the alteration of the cross section of a vertical shaft from rectangular to elliptical.

Underground Conveyors.—Paper by Harold C. Jenkins read before the Midland Institute of Mining, Civil, and Mechanical Engineers, January 31. *Colliery Guardian*, February 8.

Electric Winding Engines.—Paper by J. F. Perry, giving a comparison of various systems, and considering some aspects of the problem in the event of centralization, read before a joint meeting of the National Association of Colliery Managers and the Association of Mining Electrical Engineers, South Stafford and Warwick branches. *Iron & Coal Trades Review*, February 1.

Shaft Signalling.—At the March meeting of the Institution of Mining and Metallurgy, B. Angwin presented a paper on a "Responsive Shaft-Signal Device," describing a system devised by him at East Pool.

Manganese Ore at Cuyuna.—In the *Engineering and Mining Journal* for February 9, P. M. Ostrand describes the manganiferous-iron deposit at Cuyuna, Minnesota, and gives details of the method of mining adopted.

Drill-Bits.—The *Engineering and Mining Journal* for January 26 contains an article comparing the relative merits of Carr and cross bits.

Electric Furnaces.—Papers were read on electric furnaces at the meeting of the Faraday Society held in Manchester on February 14, of which may be mentioned: A High-Temperature Electric Resistance Furnace, by W. Rosenhain and E. A. Coad-Pryor, and Electric Steel-Refining Furnaces, by James Bibby.

Copper Determination. — The November *Journal* of the Chemical, Metallurgical, and Mining Society of South Africa contains a paper by Dr. James Moir describing a new method of determining copper, which he devised as an alternative to the process using potassium iodide, a chemical much too scarce and dear for extensive use nowadays.

Leaching Copper Ores.—In the *Engineering and Mining Journal* for February 2, G. D. Van Arsdale, chemist to the Phelps-Dodge Corporation, describes experiments in the heap-leaching of copper ores undertaken with a view to applying the method to the low-grade porphyry ores at Copper Queen and Burro Mountain mines, Arizona, and at Tyrone, New Mexico.

Properties of Copper.—*Metallurgical and Chemical Engineering* commences in its issue of February 1 the publication of Paul D. Merica's report on the physical properties of copper and the factors by which they are affected. This report was prepared for the United States Bureau of Standards.

Metallurgy of Zinc.—In *Metallurgical and Chemical Engineering* for February 1, E. M. Johnson, superintendent of the Henryetta plant of the Eagle Picher Lead Co., describes the method of crushing and jigging retort residues for the recovery of the lead and silver contained in them.

Making Zinc Retorts.—*Engineering* for February 15 and 22 contains an article relating to zinc production in this country. Among other items it describes the presses for the manufacture of retorts now being made by William Johnson & Sons, Leeds.

Metallurgy of Antimony.—At the March meeting of the Institution of Mining and Metallurgy, W. R. Schoeller presented a paper on the metallurgy of antimony, describing experiments on the smelting of comparatively low-grade stibnite ores, direct in the blast-furnace. He attributes this reduction of the sulphide to metal to the action of the blast, comparing it to the effect obtained in a copper converter.

Precipitation of Gold by Charcoal.—At the March meeting of the Institution of Mining and Metallurgy, a paper by H. R. Edmands was presented, describing the method of precipitating gold by charcoal at the Yuanmi mine, invented by the author and K. Byron Moore. This is the process described in the paper by H. G. Walton in a paper abstracted elsewhere in this issue. Mr. Edmands' paper contains an important contribution to the discussion of the theory of charcoal precipitation. We intend to deal with this subject in our next issue.

Titanium. — *Metallurgical aud Chemical Engineering* for February 1 prints A. J. Rossi's speech on the presentation to him of the Perkin medal. He gave a historical outline of his work in connection with titanium. We hope to reproduce this in our next issue.

Wolfram in Burma.—On September 8, Dr. W. R. Jones delivered a lecture at Tavoy, Burma, on the origin of wolfram aud on his preliminary investigation as to its persistence at depth in the Tavoy district.

Oil from Cannel Coal.—At the meeting of the Institution of Petroleum Technologists held on February 19, papers were read advocating the establishment of a new British oil industry, based on the production of oil by the carbonization of cannel coal at low temperatures. The authors were E. H. Cunningham Craig, F. Mollwo Perkin, A. G. V. Berry, and A. E. Dunstan. This process is now being tested by the Ministry of Munitions.

Coal and Iron in China.—The February *Bulletin* of the American Institute of Mining Engineers contains a paper by C. F. Wang on the coal and iron deposits in the Pen-hsi-hu district, near Mukden, Manchuria.

Genesis of Sudbury Ores.—The February *Bulletin* of the American Institute of Mining Engineers contains a paper by H. M. Roberts and R. D. Longyear on the genesis of the nickel-copper ores at Sudbury, Ontario.

Potash from Leucite. — In *Metallurgical and Chemical Engineering* for January 15, H. S. Washington revives interest in the many attempts to obtain potash from leucite lavas in Italy. He gives a complete and detailed review of what has been done, with a liberal bibliography.

Potash Supplies.—On February 13, Professor P. G. H. Boswell gave a lecture in Liverpool on the world's supply of potash. In the course of the lecture he referred to processes proposed for extracting potash from felspar, and to the vast deposits of potash felspar on the north-west coast of Scotland and the north-west coast of Ireland. These deposits are unfortunately difficult of access, and the mining and shipment will, in his opinion, be expensive even if practicable. Professor Boswell said he had not yet seen a commercially possible process that would extract the potash direct from this felspar, although several had been demonstrated on a laboratory scale.

Nitric Acid from Ammonia.—In the *Chemical Trades Journal* for March 2, W. G. Adam describes the contact process for converting ammonia into nitric acid devised by C. Davis and P. G. Jenkins, and developed on a commercial scale at the works of the Gas Light & Coke Co., Beckton, East London.

Water Power in Scotland.—At the meeting of the Royal Society of Arts held on January 23, Alexander Newlands, engineer in chief to the Highlands Railway, read a paper on water power in Scotland. We gave an abstract from a previous paper by Mr. Newlands on this subject in our issue of June, 1912, when we pointed out that the north of Scotland has extensive resources of water supply suitable for the generation of hydro-electric power applicable for metallurgical processes. At present the British Aluminium Co. is the only metallurgical or chemical company to take advantage of this source of energy.

Mine Taxation.—On February 25, David Bowen read a paper before the Surveyors' Institution on the taxation, rating, and valuation of mines.

RECENT PATENTS PUBLISHED.

13,996 of 1916 (112,471). E. A. CONSIDERE and C. H. BETHELL, Coventry. Improved plant for use in the treatment of tin scrap by acid and electrolysis for the recovery of the tin.

18,565 of 1916 (112,487). E. MAASS, Berlin. Adding 5% of aluminium and 3·5% of copper to zinc for the purpose of increasing its tensile strength and resistance to crushing.

935 of 1917 (112,516). S. O. COWPER-COLES, London. Improvements in the methods of electrolytically depositing copper.

5,453 of 1917 (112,876). A. A. LOCKWOOD, London. Method of precipitating gold or silver from solution, by treating the slimed ore in an agitating vat and leading the pulp and solution continuously through an adjoining vessel containing electrodes where the gold or silver is deposited. The cathodes are made of iron coated with carbon held in a varnish or tar, and the anodes of tantiron. The pulp and solution are returned to the agitator continuously.

6,687 of 1917 (112,881). W. B. LLEWELYN, H. SPENCE, and PETER SPENCE & SONS, Manchester. Improved methods of obtaining sulphate of alumina from bauxite.

4,955 of 1917 (105,559). NORSK ELEKTRISK METALINDUSTRI CO., Sarpsborg, Norway. In electric furnaces for zinc smelting, providing a rocking condenser in which the zinc powder produced is rubbed against itself and the coating of oxide removed, thus making it possible for the powder to be melted and form spelter.

NEW BOOKS

Ore Mining Methods. By W. R. Crane. Second Edition. Cloth, octavo, 280 pages, with many illustrations. Price 13s. 9d. net. New York: John Wiley & Sons; London: Chapman & Hall.

In this book the author describes in succession: the methods of support used when winning ore underground; the development by which an ore-body is cut into the requisite blocks for systematic winning; the methods of stoping, that is, of breaking the ore; the methods of handling the broken ore; the methods of mining, that is, the complete operation of winning, including breaking, supporting, and handling; open-cut mining; and, finally, the cost of mining.

It must be said at once that the book is neither easy to read nor satisfactory in description. Admittedly, to describe operations taking place in three dimensions is at all times difficult. It demands a consistent and proper use of terms, clear and convincing style, and a firm grasp of the essential features.

In the use of terms the author is loose. On page 38 it is stated that "a drift is a passage practically horizontal, begun at the outcrop and lying wholly within the deposit." Again, on page 42, "the horizontal or slightly inclined passages driven in the veins and connecting with the preliminary development are commonly designated as levels, differing from drifts in that they do not reach the surface." This conception of what constitutes a drift is not general. A drift or drive, is a gallery in the direction of the length of the deposit. The author himself does not even maintain his definition, since in Fig. 61 he shows a drift neither beginning at the outcrop nor lying entirely within the deposit. Moreover, the level which he shows in that figure would generally be considered a drift, his drift a cross-cut, while his cross-cut would be considered a sub-drift, or a box-hole.

Again, contrary to the author's conception, a level is usually taken to mean the whole of the development galleries upon a particular vertical horizon, any development workings between levels being sub-level workings. To this view, inconsistently enough, the author subcribes on page 47 where he says "The number of levels or floors is an important consideration," to which he adds lower down the doubtful statement that "in many mines it is the practice to open out a new level each month." A further instance of looseness in the use of simple terms is that of dip for the inclination of development galleries. The term dip should be reserved for the inclination of deposits, beds, or other natural planes.

In regard to style the wording is often confusing and unconvincing. The chapter on development requires to be edited.

Coming to the sequence of ideas, the author firsts describes the elements of support, the methods of stoping, handling the broken ore, and then proceeds to the description of the mining methods, under the two headings "Mining in veins and bedded deposits" and "Mining in wide veins and masses."

In detail, according to the author, the methods of stoping are those employed in breaking down the ore, namely, overhand stoping, underhand stoping, breast stoping, resuing, combined stoping, side stoping, and longwall stoping. It is to be remarked that caving, or the breaking of the ore largely by its own weight, is not included. Further, longwall stoping is described to be "that class of overhead work where the working face is parallel with the levels" and "just as often employed in steeply inclined veins. . . ", a description with which few will agree.

As apart from the methods of stoping, the author states that common usage considers the complete operation of working the deposit, supporting the workings, and handling the ore, to constitute the method of mining. Of the various methods, he describes under "Mining in veins and bedded deposits" the following succession: mining bedded deposits by the use of props; mining mineral veins by the use of stulls; mining mineral veins by the use of square sets; mining mineral veins by the use of filling; mining bedded deposits by caving. And under "Mining in wide veins and masses" the following: shrinkage methods; square-set methods; filling methods; and caving methods. In this plan of description the support of the excavation has apparently been the determining factor. Yet this should hardly be so, since the end purpose of any method of mining is not the support of the excavation, nor even the breaking of the ore, but the successive winning of unit portions of the deposit till all possible under the particular method shall have been won. Along such a line the following methods would find place: back or overhand, floor or underhand, longwall, top-slicing, sub-level, pillar-and-stope, bord-and-pillar, block, and chamber mining. In many cases, however, the characteristic feature of a method will be the method of breaking the ore, and here overhand, underhand, undercutting, and caving methods are distinguished. While finally would come those methods where the support of the excavation would be the predominating feature, namely: the prop, stull, square-set, pillar, filling, and shrinkage methods.

In conclusion, the author has rendered understanding more difficult by describing actual operations in particular cases, while leaving to the reader the burden of assembling the general descriptions. Commendation must however be given for the completeness of the bibliography presented, while the fact that the book is a second edition is evidence that it is appreciated.

S. J. TRUSCOTT.

Quin's Metal Handbook. By L. H. Quin. Price 3s. 6d. net. London: The Metal Information Bureau, Ltd. This is the fifth annual issue of a convenient handbook for the metal trade. It gives statistics of production, etc., of the commercial metals, with records of prices throughout the year. The advertisements of business houses and smelters also provide much useful information.

Refractory Materials: their Manufacture and Uses. By Alfred B. Searle. Price 15s. net. London: Charles Griffin & Co. Ltd.

The New Zealand Mines Statement for 1916. By W. D. S. MacDonald, Minister of Mines.

The West Australian Geological Survey has published the following: Geology and Ore Deposits of Meekatharra, Murchison Goldfield, by E. de C. Clarke, R. A. Farquharson, and E. S. Simpson; Contributions to the Study of the Geology and Ore Deposits of Kalgoorlie, Part 3, by F. R. Feldtmann; Paleontological Contributions to the Geology of Western Australia, by F. Chapman and R. Etheridge; Annual Progress Report of the Geological Survey for 1916.

The British Guiana Government has published reports on the Occurrence of Reputed Petroliferous Areas in the North-Western and Pomeroon Districts, and on Bauxite in British Guiana, 1910 to 1917.

Journal of the Iron and Steel Institute, Vol. 96. This contains a report of the proceedings at the autumn meeting 1917, together with two reports by technical committees.

COMPANY REPORTS

Wankie Colliery.—This company was formed in 1899 to develop coal deposits in Southern Rhodesia, between Bulawayo and Victoria Falls. The company is housed with the British South Africa Co., Edmund Davis is chairman and managing director, and A. R. Thomson is manager in Rhodesia. In the early days the venture was not successful financially and the shares were written down from £1 to 10s. Shortly afterward, however, prosperity arrived, and the old capitalization was restored by giving two 10s. shares in place of each one held. An important accession of business came from the Union Minière du Haut Katanga, and more recently the requirements of the Rhodesia Broken Hill have added to the business of the company. The report for the year ended August 31 last shows that 527,684 tons was raised, from which 92,194 tons of shale and other earthy matter was removed; 310,826 tons was sold, 111,875 tons was used in coke manufacture, and 12,789 tons was used for steam-raising and brick-making. The coal sales showed an increase of 41,949 tons as compared with the previous year, and would have been still greater but for interruptions in railway transport. The reserve of coal proved by forward development work is estimated at 2,600,000 tons, and in addition 1,700,000 tons is left in main drive pillars. Developments during the year have continued to expose good coal, though in certain sections the seams are much faulted and occasionally consist of dirty coal. During the year, 25,237 tons of coke was made in the beehive ovens and 50,494 tons in retorts. A further 56 retorts are under construction. Owing to the water supply having proved insufficient, an additional supply from the Deka river has been brought in. The accounts show an income of £230,543, and a net profit of £71,202, out of which £40,523 has been distributed as dividend, being at the rate of 10%. It is proposed, subject to Treasury sanction, to issue 380,000 new shares of 10s. each, for the purpose of replacing funds drawn from revenue during the last few years and used for extensions of operations, and also to provide for additional funds required for further increases in the output of coal and coke.

De Beers Consolidated.—This company was formed in 1888 to consolidate diamond-mining operations at Kimberley, Cape Province. Production was suspended on the outbreak of the war, and was not resumed until early in 1916. The report now issued covers the year ended June 30, 1917. At the Wesselton mine the output was 1,814,393 loads, and on the floors 1,669,104 loads were washed, yielding 450,600 carats, being 0·27 carat per load. At the Bultfontein, 2,092,297 loads were hoisted, and 1,761,756 loads washed, for a yield of 669,500 carats, or 0·38 carat per load. At the Dutoitspan, 135,650 loads were raised, and 1,957,335 loads were washed, for a yield of 371,900 carats, or 0·19 carat per load. The total yield was 1,492,000 carats. At the washing floors the ground in stock for treatment was 2,752,386 loads at the Wesselton, 2,665,777 loads at the Bultfontein, and 2,411,618 loads at the Dutoitspan. The accounts show an income of £4,629,771 from the sale of diamonds, and a profit of £2,971,586. The dividends on the preferred shares absorbed £1,200,000, and on the deferred shares £1,000,000, both being at the rate of 40%.

Kampong Kamunting Tin Dredging. — This company was formed in Sydney, New South Wales, in 1913 to acquire alluvial tin ground at Kamunting, near Taiping, Perak, Federated Malay States. The first dredge started in March, 1915, and a second in February, 1916. The report for the half-year ended June

30, 1917, shows that both dredges worked well during the period. No. 1 dredge treated 4,506,000 cu. yd. for a yield of 224 tons of tin concentrate, and No. 2 497,000 cu. yd. for 236 tons. The total output was 460 tons, selling for £51,872. The net profit was £29,281, out of which £21,000 was paid as dividend, being at the rate of 15%, while £7,500 was placed to reserve. The costs at this mine include depreciation of plant and amortization of the property.

Tincroft Mines.—This company was formed in 1900, as the Carn Brea & Tincroft Mines, to work a group of mines between Redruth and Camborne, that had previously been worked for many years under the cost-book system. In 1916 the Carn Brea section was abandoned, the name changed, and the capital written down. At the same time new shares were issued to provide additional working capital for development. The report for the half-year ended December 31 shows that the tin content of the ore treated was lower than ever, but that the sales of arsenic brought an unusually big income, making it possible to distribute a substantial dividend. The ore treated was 28,747 tons, and the yield of tin concentrate 215 tons, being 16·77 lb. per ton. The tin concentrate sold for £30,758, and £25,018 was received from the sale of arsenic. In addition £2,148 was received for wolfram concentrate and £332 for copper concentrate. The total receipts were £59,922, the working cost £46,806, lord's royalty £1,725, and the net profit £11,389. Out of the profit £1,677 is allowed for depreciation of plant, and £5,000 is distributed as dividend on the priority shares. The capital of the company is 96,953 ordinary shares of 5s. each and 50,000 priority shares of 5s. each, and there are £10,000 debentures.

Kinta Tin Mines.—This company was formed in 1900 to acquire alluvial tin properties on the eastern side of the Kinta valley, Perak, Federated Malay States. W. A. Luning is the chairman, and Osborne & Chappel are the managers. Satisfactory dividends have been paid continuously. Four years ago the company joined with the Gopeng in a scheme for obtaining water at higher pressure from the Kampar river. The report for the year ended June 30 last shows that 999,000 cubic yards of ground was worked, for a yield of 548 tons of tin concentrate, selling for £60,879. The net profit, after writing £7,000 off the cost of the Kampar line, was £25,134, out of which £24,000 has been distributed as dividend, being at the rate of 20% free of income tax. The yield per yard was 1·23 lb. and the working cost per yard was 6¾d.

WANKIE COLLIERY CO., LTD.

Directors: Edmund Davis (*Chairman and Managing Director*), H. Wilson Fox, D. N. Shaw, William Rhodes, H. L. Stokes. *Secretary:* A. W. Bird. *Office:* 2 London Wall Buildings, London, E.C.2. *Manager in Rhodesia:* A. R. Thomson. *Formed* 1899, reconstructed 1914. *Capital:* £405,236 in shares of 10s. each; debentures £79,000.

Business: Works a colliery in Rhodesia, and manufactures coke.

The third ordinary general meeting of the Wankie Colliery Company, Ltd., was held on February 12 at Salisbury House, London, E.C., Mr. Edmund Davis (Chairman and Managing Director of the company) presiding.

The Chairman, in moving the adoption of the report and accounts for the year ended August 31, 1917, said that the sales of coal, coke, bricks, and fireclay amounted to £228,185, being an increase of £36,017 when compared with the receipts under this heading for the year ended August 31, 1916. The sales of coal and coke for the year were respectively 527,684 tons and 70,827 tons, comparing with 459,957 tons of coal and 45,964 tons of coke for the previous year, an increase of 67,727 tons of coal and 24,863 tons of coke respectively. The result of the year's operations was a balance profit of £71,202, as compared with £57,730, an increase of £13,472, but this balance was subject to a charge for excess profits duty, which at the moment could not be determined until the questions outstanding between the company and the authorities had been settled. As far as the present year's operations were concerned, they had produced and sold during September, October, November, December, and January 150,672 tons of coal and 35,431 tons of coke, these comparing with 135,592 tons of coal and 29,200 tons of coke for the corresponding months covered by the previous accounts. They had continuously increased the sales and were looking forward to further demands for coal and coke. But this meant a constantly increasing output, which could only be maintained if the plant and equipment were gradually added to. They had had to rely upon working profits to supply the funds which had to be provided to supply the constantly improved and enlarged equipment. This, however, could not continue indefinitely, and they now proposed an increase of capital of the company and an issue of shares. As regards capital expenditure already incurred, a very large amount had been outlayed during the period covered by the accounts, but to this should be added £21,973 included in the eight months ended August 31, 1915, and £22,098 for the twelve months ended August 31, 1916, these, together, with the amounts included in the present accounts, making a total of £92,071, to which had to be added capital expenditure incurred since August 31, 1917. At their last meeting reference was made to the water supply at the colliery, which had at all times been very unsatisfactory. Had it not been for their decision to connect the colliery with a permanent water supply at a cost of over £32,000 the whole of their operations would have been brought to a standstill on October 22, 1917, when the Deka dam ran dry. The water from the permanent supply was brought into the colliery on September 27, 1917, a distance of about nine miles, through an 8½ in. pipeline, and since the advent of this supply they had had no further anxiety in this respect. In addition to this water service, the principal capital expenditure being incurred was in connection with the erection of 56 new retort ovens, and when these were completed—which should be at the latest by August next—the output of coke from the retort plant alone should be about 10,000 tons per month, and given sufficient small coal and the working of the beehive ovens to the full capacity, the total output of coke should be about 12,500 tons per month, which was not equal to the present demand. The board intended to make application to the Treasury for permission to issue 324,190 new shares of 10s. each at 10s. 6d. per share, and to pay an underwriting commission of 6d. per share for the guaranteeing of the subscription of the capital. The proceeds would be utilized to cover capital expenditure so far incurred, which had already been referred to, and to provide additional funds required to complete the plant they had arranged to erect, though they had so far met the major portion of the capital expenditure incurred out of their available resources. They must replace that capital previous to making any further distribution of profits in respect of the year which ended on August 31 last. If, and when, Treasury consent to the issue was obtained—and immediately after the issue—they intended to distribute a dividend of 5%. In connection with profits, they wished to draw attention to, and at the same time bring to the notice of their customers in Rhodesia, the fact that, though working expenditure had shown an increase, and though a very large amount of additional capital had had to be provided, they had not raised the price of coal, which was sold at prices varying between 7s. 6d. and 9s. per ton at the colliery. They trusted that the Treasury would give its consent to the issue referred to at an early date, as what they had done in the past in the way of increase of plant and what they were completing at the moment was principally with a view to supplying their customers who bought coke, these in particular being the Union Minière du Haut Katanga, which produced copper, and the Rhodesia Broken Hill Development Company, Ltd., which produced lead, both commodities being urgently required for war purposes. Their capital expenditure under present circumstances was more patriotism than business, and was a policy which, they felt assured, would meet with the unanimous approval of the shareholders. He need only point out that the cost of plant, its transport, and its erection under existing circumstances meant greatly enhanced cost incurred to supply coke to provide supplies of metals for Government purposes, and that, unless they obtained a very large rate from the Board of Referees, the Government would be receiving by way of income tax and excess profits duty practically the whole of any surplus. There was only one other matter to which he particularly wished to refer at that meeting, and that was the devoted attention of their general manager, Mr. Thomson, to the operations of the company, and to the satisfactory work of his staff and all those employed at the colliery, who were now dealing with a much larger business in as satisfactory a manner as in the past.

Mr. H. Wilson Fox seconded the motion, which was carried unanimously.

KINTA TIN MINES, LTD.

Directors: W. A. Luning, A. Joshua, F. H. Aarons. *General Managers:* Osborne & Chappel. *Secretary:* H. Percy Hood. *Office:* 65 London Wall, London, E.C.2. *Formed* 1900. *Capital* £120,000
Business: Operates an alluvial tin mine in Perak, Federated Malay States.

The annual general meeting of the Kinta Tin Mines, Ltd., was held on February 13 at the registered offices of the company, 65 London Wall, London, E.C., Mr. W. A. Luning presiding.

The Chairman, in moving the adoption of the report and accounts for the year ended June 30 last, said that during the period the output of tin had been 548 tons, as against 476 tons for the year ended June 30, 1916, and 254 tons for the year ended June 30, 1915. The average price obtained had been £111, against £101 and £89 respectively. The gross value of the ore had been £60,879, as against £48,017 and £22,584 for the two previous years. The mining costs had been £27,749, as against £18,561 and £8,405 for the years to June 30, 1916 and 1915, respectively. The net profit accruing to the company, without taking into consideration depreciation, had been: for the present year £32,384, for year to June 30, 1916, £27,361, and for year to June 30, 1915, £11,011. During the period ended June 30 last, the London price of metallic tin was in July, 1916, approximately £170 per ton. The market continued to rise steadily without a setback of any importance until June, 1917, when it reached the figure of £240 per ton. These figures had been entirely put into the shade, and might almost be regarded as lean months compared with the prices which had ruled since the closing of the accounts. In July, 1917, the price was £235, and it continued to rise steadily until January, 1917, when it reached what might be called the bumper figure of £295 per ton. When shareholders saw these figures, they were naturally surprised to find that the company obtained an average of only £111 per ton last year for the product. The ore was sold in the Malay States; therefore, freight, insurance, and export duty had to be allowed for, bringing the local price of the metal to anything between £25 to £30 per ton below the quoted London price.

The profit for the year, as already mentioned, amounted to £32,384, which, after allowing for depreciaton, income tax, etc., left the amount available for distribution £22,653. An interim dividend of 10% had already been paid, and they recommended a distribution of a final 10% making 20%, free of income tax, equal to 26⅔% gross for the year, leaving £1,274 to be carried forward. The total cost of the new water service payable by their company, including the share of the construction, plant, fittings, and superintendence, and the expenses of the issue of new shares for raising the capital in the year 1912, amounted to £91,100. In the year 1916 they wrote off from their profits an amount of £7,000. This year they had written off a similar amount of £7,000, and with the share premium and reserve accounts they had written off no less than £30,000, making the total written off £44,000, leaving the book value of the construction account as per the balance sheet £47,100. The following amounts had been written off this year: Kampar Waterworks, £31,000; underwriting account, £6,000; battery and electric light plant, £250; making a total for the year of £37,250. After thus drastically dealing with the figures, the balance sheet became quite simple, without any complications or unreal items, and one which would appeal to shareholders. The total authorized and issued share capital was £120,000, as shown on the liability side, which was represented on the assets side by the property account (including the total expenditure on the Kampar water scheme, less £31,000 amounts written off, as already mentioned) of £119,687, which was approximately equal to the share capital.

Dealing with the question of mining costs, these included a heavy charge of some £10,728 for upkeep of the old and new water lines and dams, an amount considerably in excess of the cost incurred in previous years. The new water installation was treating proportionately a much greater quantity of ground than the original water service—a very modest affair indeed compared with the present enormous installation; consequently heavier expenses had been, and would have to be in the future, incurred for the upkeep of dams. The stringent regulations made by the Federated Malay States Government for the protection of agricultural and other lands in the neighbourhood of mines rendered it necessary that all slime should be impounded and controlled.

Many shareholders had expressed their anxiety as to how this company would fare in the matter of excess profits. After submitting detailed figures and putting a special case before the surveyors, they had secured a satisfactory allowance from the assessment for income tax on account of the not inconsiderable question of depreciation of the water service. The total cost of construction (as apart from cost of obtaining the new capital) was agreed at £83,890, which sum was to be allowed from the assessment spread over a period of some 20 years. Calculated on this basis, they obtained a deduction from their annual profits of £4,195 for 20 years, both for income tax and excess profits duty.

In conclusion, he had pleasure in recommending shareholders to record their appreciation of the services of Messrs. Osborne and Chappel. The affairs of the past four or five years had occasioned them and their assistants great anxiety and labour. In a tropical climate the construction of this enormous pipe line involved great difficulties at times, but one and all associated with the general managers and with the company very cheerfully faced these and other troubles with confidence and self-reliance, and they had been rewarded by the completion of this arduous work in a manner that reflected the highest praise on all concerned. It was difficult, not to say well-nigh impossible, to give any idea as to the life of this property. It had now been in operation for over 15 years, and when one came to look at the working plans one realized that but a very small part of the total area of the company's mine had yet been dealt with, and that portions which years ago appeared to be unprofitable to work had now been brought into the realm of practical politics, thanks to the installation of the new water service.

Mr. J. H. Borrer seconded the resolution, which was carried unanimously.

Mr. C. H. Hanrahan proposed the re-election of Mr. W. A. Luning, the retiring director, and the motion was seconded by Mr. G. Townsend and unanimously agreed to.

Messrs. J. M. Henderson and Son were reappointed auditors, on the motion of Mr. F. D. Bain, seconded by Mr. J. Pomeroy.

The proceedings then terminated.

NEW LAFON TIN FIELDS, LTD.

Directors : Frederick Walker *(Chairman)*, James Fairbairn, Charles Wallington, A. H. Wethered. *Secretary :* C. E. Townsend. *Office :* 6 Broad St. Place, London, E.C. *Manager :* A. A. Davidson. *Formed* 1914.
Capital : £35,738 in shares of 2s. each.
Business : Operates alluvial tin properties in Nigeria.

The third annual general meeting of the New Lafon Tin Fields, Ltd., was held at Winchester House, London, E.C., on February 27, Mr. Frederick Walker (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts for the year ended September 30, 1917, said that the profit was £1,996, as compared with £246 last year, showing an increase of £1,750. On the credit side of the account, the tin sold had realized £7,514, as compared with £3,430 for last year, showing an increase of £4,084. That was partly due to the larger amount of tin won, but also to the enhanced market price of tin. They had now, he was thankful to say, no bills payable. The company was, in fact, free from debt, excepting for the ordinary current liabilities incident to carrying on the company's business. On the assets side the purchase of property and development of estate stood at the same figure as last year.

Shareholders would expect him to give his opinion as to how far the progress of the company toward financial soundness and respectability was any indication of the possibility of the company entering the list of dividend payers. From the great advance in the market price of the shares he was inclined to think that some people took a more optimistic view of the company's prospects than was evidenced by the figures in the company's balance sheet. Some people, apparently, were obtaining cablegrams from outside sources on the other side, and were acting on them. He sincerely hoped that the future would justify, and more than justify, hopes founded on these outside tips, but the directors could accept no responsibility for them. What information they had they were only too pleased to place at the disposal of shareholders, but hopes based on tips from outside operators—however well-founded they might chance to be—were not hopes for which the directors could reasonably be held responsible. All he could say was that in the future, as in the past, no trouble, no care, no effort would be shirked by the directors to do what in them lay to make these hopes come true. When, at the earnest solicitation of Mr. Fairbairn, he consented, with no little anxiety, to join the board and to accept the responsibility of occupying the chair, the prospects of the company were gloomy indeed. It was manifest that the company's original property—on which such glowing hopes were founded—was not fulfilling, and was never likely to fulfil, the expectations founded on it, and, so far as he could gather from the first meeting over which he presided, the shareholders had little hopes of any improvement. He at once decided to reduce all expenses to the narrowest possible limits. With the cordial concurrence of his colleagues, he cut down the by no means extravagant directors' fees to one-half and dealt equally drastically with secretarial and office expenses, but he recognized that, though this might slightly prolong the patient's life, it would not effect a cure, and that, if the company was to be saved, an additional tin area must be secured. Unfortunately, they had no money to purchase the additional property on which he had set his heart, and the attempt to buy these mining rights on tick was hardly one on which he could enter with many hopes of success, but here Mr. Fairbairn's fine diplomatic abilities stood him in good stead and, with the zealous co-operation of Mr. Oliver Wethered, they pulled it off, and actually bought the additional area with promissory notes, which he could hardly hope to meet except out of the tin to be won from the same area. It was the nearest approach he ever experienced to the proverbial exploit of buying a goose and paying the price out of the bird's own feathers. He was thankful to say the promissory notes had all been met and, as they said in the report, the company was now out of debt. At the same time they could not expect to do that sort of thing again, and he was convinced that, if they could secure sufficient prompt cash to be able to take up and work any promising new areas that might from time to time be available, and to spend money with no niggard hand in prospecting operations, the company would have a good prospect of becoming a success. The question was, how they were to secure this additional capital. They had 92,593 unissued shares of 2s. each, but without Treasury sanction they could not issue them so as to make them good delivery on the Stock Exchange. They had, however, succeeded in getting an offer which they ought unhesitatingly to accept. It was an agreement to take these shares, as and when they could legally issue them, partly at par and partly at rising premiums, so that in the end they would yield not simply £9,259, their face value but about £11,788, and of this amount £1,000 would be paid in cash down on the signing of the agreement and the rest they would have power to call, on reasonable notice, if the directors found they had need of it, in order to secure additional areas or to adequately work areas already secured. It would not have been possible to secure such a favourable offer as this except from people who were already so interested in the success of the company that they did not hesitate to place at the disposal of the directors the capital which they were satisfied was essential to that success and which they were good enough to think would not be unwisely expended by those directors. This offer seemed to open a chance of the company achieving permanent success. A cablegram just received from the other side, relating to the areas which were referred to in the directors' report, said : "Area proved covers length 300 ft. by 250 ft., average value 4 lb. over depths from 8 to 10 ft , highest value 18 lb. over 9 ft., lowest 2 lb., values continuing, looks most promising for extensive deposits."

Mr. Charles Wallington seconded the resolution, which was duly carried.

Mr. James Fairbairn spoke in appreciative terms of the excellent services rendered by their manager in Nigeria, Mr. A. A. Davidson.

Mr. White moved that the directors should resume their normal fees instead of taking only half fees. Now that the company had turned the financial corner it was only right that the board should be properly remunerated for the arduous work they had done for the company.

This resolution was seconded and carried unanimously, and after acknowledgment by the Chairman, the meeting terminated.

TINCROFT MINES, LIMITED.

Directors: James Wickett (*Chairman*), T. Robins Bolitho, Horton Bolitho, John Gilbert, Harry Rich, Captain W. D. Coode. *General Manager:* W. Thomas. *Secretary:* F. E. Martin. *Office:* Carn Brea, Cornwall. *Formed* 1900. *Capital:* £24,258. 5s. in ordinary shares, and £12,500 in priority shares, both of 5s. each; debentures £10,000.

Business: Operates a tin-wolfram-arsenic mine between Camborne and Redruth, Cornwall.

The 36th ordinary general meeting of the Tincroft Mines, Ltd., was held at Redruth, on February 19, Mr. James Wickett presiding.

The Chairman, in moving the adoption of the report and accounts for the half-year ended December 31, said it was scarcely necessary to say how pleased he was to meet shareholders under circumstances so different from those that had prevailed in former years. There had been times in the history of their mine when all the optimism of which he was possessed had to be called into requisition to keep the shareholders in heart and inspire hope in the future. Some of his friends had said years ago that he was getting old, and should abandon the task of getting the mine out of its difficulties, but his reply was that he had stood by it for many years, and the chances were that after all he might live to see the success of the Tincroft mine. He was thankful now to meet them under circumstances so greatly altered for the better. In fact, the mine was looking better than at any time since he had been chairman of the company. It was pleasing that they were producing stuff to-day that was worth £2. 1s. 8d. per ton. Such a result had never been arrived at in their experience before. If they looked at the report they would observe that the produce of tin returned had been less than usual, and Captain Thomas explained why such had been the case. It had been due to no particular alteration in the progress of the mine, but simply to the fact that in consequence of the intrusion of large quantities of arsenic they had been compelled to stamp tinstuff that only contained a very small quantity of that metal, but which had been fairly rich in arsenic. The statement of accounts showed that they had made a profit of 7s. 11d. per ton, the like of which had never been done before. The accounts also showed that they had spent a fairly large sum in renovating the plant. Had they been as successful as some of their neighbours much of this work would have been done earlier, but in the past they had not had the necessary funds with which to set their house in order, but he hoped that in the natural course of things they might have dressing floors at Tincroft which would be a credit to the mine and to the management. He would not give much for a man who went into mining who was not prepared to take a fairly optimistic view of things. The unlikely suddenly happened in mining, and with tin as it was now at considerably over £300 per ton, they had a state of things such as he never anticipated. What the future was going to produce he thought it would be very unwise foı anyone to predict; but they knew that after the war there must of necessity be a very good demand for tin. Stocks on the continent and all round must of necessity be bare, and when the desolated towns and cities of France, Belgium, and elsewhere came to be rebuilt it would certainly lead to a large demand for metals, so they might safely calculate in the years to come they would have a fairly satisfactory price for all the metals they produced. So far as arsenic was concerned, they had been wonderfully fortunate. They had made a large quantity of it, and the average had been worth 17s. 4½d. of all the stuff treated.

Mr. John Gilbert seconded the motion, and, after Captain W. Thomas had given particulars of developments, the motion was put to the meeting and carried unanimously.

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EDITORIAL

THE use of gold for anything but bankers' requirements is to be strongly deprecated in these days. The Royal Geographical Society has recognized this position by deciding to strike its medals in bronze instead of in the precious metal. Its example should be taken to heart by the nation. Unfortunately the requirements for personal adornment, whether in the form of jewelry for the munitioner or gold braid for the fighter, draw far too largely on our bullion resources.

LAST month we referred to Lord Cowdray's offer to conduct boring operations for petroleum in Great Britain. Since then it has been announced that two likely places have been selected, and that drilling will be commenced without delay. We also mentioned that, at a meeting of the Institution of Petroleum Technologists, strong recommendations were made for the production of motor spirit and fuel oil from cannel coal. In this connection, the Institution has appointed a committee of inquiry and investigation, with offices at Trafalgar Buildings, Charing Cross.

INFORMATION relating to tin-mining operations in Nigeria has never been plentiful. For this reason our readers will welcome the article appearing in this issue on the mines and properties of the Northern Nigeria Bauchi Company, written by Major A. R. Canning. This company had a tough struggle in the early days, but under Major Canning's management has "made good." The general interest in the work done is considerably enhanced by the fact that the company is intending to erect a hydro-electric power station at the Kwall Falls, the only spot in the region where there is sufficient water supply for such a project.

FROM the annual report of the Council of the Institution of Mining and Metallurgy, excerpts from which are given on another page, it will be seen that the taxing authorities have succeeded once more in their tactics of splitting the forces arrayed against them. It was genuinely believed by the Council that the two cases submitted by them to the consideration of the Board of Referees in connection with the incidence of the excess profits duty on mining companies were to be considered as representative of the whole metalliferous mining industry. The test case in connection with gold undertaken by the Institution related to West African mining. It is true that the Referees agreed to raise the statutory percentage from 6% to 22½%, but they gave no details as to the principles on which their ruling was founded, and, indeed, they do not appear to have acted on any of the methods of computation submitted by the Institution. Under these circumstances the Council has abandoned the other test case, that relating to copper mining, for the work would obviously lead to nothing but a waste of time.

IN our December issue we referred to the sale of Dr. G. E. Morrison's library of books relating to China to a Japanese nobleman. By an incorrect interpretation of an item of news received from the Far East, we referred to him as the "late" Dr. Morrison. Thus he has been killed prematurely for the second time, the first operation having been performed by an obituary notice published in *The Times* on the occasion of the massacre of Peking. Six years ago he left the position of *Times* correspondent to become confidential adviser to the Chinese Government. For the last few months he has been touring Australia, the land of his birth. Having already made a wrong inference with regard to him, it would be rash on our part to speculate as to the reasons why he sold his library, or the price and other conditions of sale.

South Crofty.

The meeting of shareholders of South Crofty, Limited, held just before the Easter holidays, was as pleasant a function as it was ever our privilege to attend. This mine does not possess the historic glamour of its neighbour Dolcoath, and it has not yet had the luck to strike a bonanza like its neighbour on the other side, East Pool & Agar. In fact its road to prosperity has been a difficult one, for the ore is hard, complex, and of low grade. Fortunately the board, of which Mr. Francis Allen is chairman, appreciated the vital necessity of having adequate working capital, both by original subscription and by allocation from current profits. The company also has the inestimable advantage of possessing, in Mr. Josiah Paull, an excellent manager. An idea of the operations may be given by quoting the results for 1917. The ore sent to the mill was 70,055 tons, and the yields of tin concentrate, wolfram concentrate, and white arsenic were 610 tons, 87 tons, and 828 tons respectively. A small amount of copper concentrate was also saved. The yields per ton of the three products were 19·5 lb., 2·8 lb., and 26·5 lb., and the receipts per ton accruing from them were 24s. 1d., 4s. 2d., and 11s. 6d. respectively. The cost per ton at the mine was 25s. 7d. After deducting all expenses, and allowing for depreciation, the net profit was £41,530, out of which £35,000 was distributed as dividend, being at the rate of 70%, free of income tax. Of the announcements made at the meeting, one related to the production of arsenic. This article used to be merely a troublesome by-product, but it is now affording a substantial increase in revenue, the figure for 1917 being £40,388, comparing with £84,438 received from the tin concentrate. The mines usually sell their arsenic as soot, but South Crofty has established a refinery, and now places the "Feathers" brand of refined arsenic directly on the market, thus reaping the great advantages of higher prices and greater freedom of sale. The other announcement related to the prospecting operations that have been conducted for a year or more with the object of finding the continuation of the Rogers lode from over the East Pool border. This prospecting has so far been done by cross-cuts. Two months ago a lode was intersected on the 225 fm. level assaying 15 lb. of black tin per ton and 1% of arsenopyrite. The lode was 3 ft. 6 in. wide at this point, and much broken. At the meeting, Mr. Paull reported that he had driven on the lode and that the latest results indicated a substantial increase in the assay-value. For 20 ft. driven east and west the average content is 34 lb. of black tin and 3% arsenic over a width of 5 ft., while the part of the lode to the east for a width of 2 ft. gave by vanning assay 84 lb. of black tin and 8% arsenic. It is not known yet whether the lode is the Rogers, but probably it is not. Subsequent exploration is to be done by the Sullivan diamond-drill, which has just arrived at the mine, and the first bore will be driven from the face of the 225 fm. cross-cut with the object of ascertaining whether the Rogers lode lies still farther to the north. Another pleasant feature of the proceedings was the acknowledgment of valuable assistance given by Mr. M. T. Taylor, of East Pool, in connection with the exploratory work, the interpretation of the results, and the general geology of the district. The speeches at the meeting made by Mr. Allen and Mr. Paull were closely followed by shareholders, who at the close of the proceedings marked their appreciation of the labours of the directors by voting them an additional £500. The Chairman, in acknowledging the compliment, expressed a hope that next year shareholders would meet under happier circumstances; but that remark, let us add, did not refer to the immediate business of the meeting.

Iron Ore in the Midlands.

The article by Mr. W. Barnes in our last issue describing the methods of mining the Jurassic iron ores in the Midland Counties has aroused much interest, and several readers have asked for additional information relating to the nature and thickness of the ore and of the overburden, and the amount of explosives required to break the ore before digging. There are wide variations in connection with these items, both as regards occurrence and practice. The overburden in the Frodingham and Scunthorpe districts of North Lincolnshire consists almost entirely of sand, peat, and a shaley clay, all very easily worked, and varying in thickness from a little over a foot to some scores of feet. It is not possible at present to use the open-cut method if the depth of overburden is more than about 50 ft. Some improvements may be made in the method, so that probably depths of 60 to 80 ft. may be worked in this way eventually, but ore lying at greater depths will have to be mined by underground methods. Farther to the south, in central Lincolnshire, by Lincoln and Leadenham, the overburden is hard, consisting mainly of limestone, and the open-cut could not be carried below 30 ft. As a matter of fact, most of the ore in this district is won by underground mining. In south Lincolnshire, and on into Northamptonshire and Leicestershire, the overburden varies from ordinary soil to heavy blue clay and even limestone, in thicknesses from a few feet to depths too great for the open-cut. Nearly all the mining here is done by open-cut at the present time, and the only underground workings are at the Finedon and Irthlingborough districts, near Wellingborough, Northamptonshire. In the Banbury district, by the boundary of Oxfordshire and Northamptonshire, practically all the iron ore lies within three feet of the surface. With regard to the iron ore beds, these vary in thickness from three to 30 ft. In the Frodingham district, the ore is calcareous and comparatively hard, so that a fairly liberal use of explosives is required, in order to loosen it for the excavating machines and also to break it into lumps small enough for the furnaces. In the Banbury district the ore is of similar nature, but the thickness is not so great, 12 ft. being an average, and the maximum 20 ft. In the other districts, some of the ore requires the aid of a small amount of explosives, and in the remainder, the ore is loose and earthy and can be handled without the use of explosives. In some quarries it is only necessary occasionally to blast in front of the excavating machine. The explosives employed vary according to requirements, but gelignite and ammonite may be mentioned. The practice at the mines varies so much, according to the particular conditions, that no characteristic average estimate can be made of the amount of explosives required, and at the present time it is inopportune to discuss the general cost of mining.

The Institute of Metals.

The tenth annual meeting of the Institute of Metals, held in London last month, was of more than usual interest to the readers of this Magazine, owing to the fact that the president this year is Dr. H. C. H. Carpenter, the professor of metallurgy at the Royal School of Mines. The personal note is not by any means confined to the recital of this bare fact, for it also has to be recorded that part of the credit for the establishment of the Institute is due to Dr. Carpenter himself. It is appropriate that at the end of the first decade some sort of review of progress should be made, and this Dr. Carpenter did in his presidential address. The impetus to the formation of the Institute was given in a letter addressed to our contemporary, *Engineering*, by Mr. W. H. A. Robertson, of Bedford. The hint took effect rapidly, for the metal community was ready for it. In Dr. Carpenter's words, Mr. Robertson's letter acted with the swiftness of a crystal placed in a supersaturated solution. On February 8, 1908, a dozen men interested in these matters met in Manchester, and rapidly evolved plans for the foundation of a society for the advancement of scientific and technical study of the engineering side of non-ferrous metallurgy. The honorary secretaries of the committee then formed were Dr. Carpenter, who was at that time lecturer on metallurgy at Manchester University, and the late Mr. W. H. Johnson, a member of a well known firm of brass-founders and wire makers. The first step taken by the committee was to consult the late Sir William White, who was at that time chief constructor for the Navy, with the object in the first place of obtaining his views, and in the second of securing his services as president. Sir William pointed out the desirability of keeping a fair balance between the manufacturers and the scientists, and advised that the council should be composed of equal numbers of representatives of the "trade" and of those engaged in scientific research at university laboratories or similar institutions. This policy has been an undoubted success, and both branches of the "profession" have been the gainers by the mutual intercourse on the basis of equal footing. The membership has steadily mounted, until at the end of 1917, the number was 888. The scope of the Institute is clearly defined as the scientific discussion of the behaviour and uses of metals after they have been extracted from the ores, and in this way the interests supplement those of the Institution of Mining and Metallurgy. Thus most of the papers are not of direct personal interest to the majority of our readers, though in the list of officers and members of council we see the names of many of our friends, such as Professors Carpenter, Turner, Huntington, and Gowland, and Sir Thomas K. Rose. One of the notable features of the activity of the Institute is the publication of the Journal, which appears twice a year. In addition to the papers read at the spring and autumn meetings, these volumes contain excellent abstracts of the world's literature. Another important undertaking of the Institute is the Corrosion Research. These investigations are in the hands of Dr. G. D. Bengough and Dr. O. F. Hudson, and with aid of a grant from the Treasury the work has recently been expedited and widened by these two metallurgists being able to devote the whole of their time to the research. The investigations are being made partly at a new laboratory at the Royal School of Mines, and partly at the Southwick power-station at Brighton. The problems in hand are of very great importance in metal circles, and the organization of the research reflects great credit on so young an Institute. Before concluding this brief review of the services rendered to the community by the Institute, we wish to draw attention to the thoughful remarks made by Dr. Carpenter in his presidential address in connection with methods of education. Space does not permit of any lengthy extract or reference, but there is one of his points that we should like to mention, just for the purpose of confirming it. He says that students can and do educate each other, and that the difference in standard between succeeding years of students may be attributed to the presence or absence of a student or students of more than average ability. Our own experience leads us to the same conclusion. We well remember that in the engineering lectures, when our professor took his class beyond their depth, the students were not dismayed, but on the termination of the lecture asked the head man to interpret and explain. That student was a most valuable unofficial and unrecognized member of the teaching staff.

The Search for Ore.

Though our policy has always been to encourage the application of geological science to prospecting for ore deposits, we have not been unmindful of the fact that chance will continue to be the dominating factor of success in the search for underground wealth. To put the matter in another way, all that the geologist can do for the miner is to indicate where the chances of finding ore are the greatest and also the least, and thus to direct human effort along the most promising channels and eliminate the ignorant and dishonest element of waste. One of the most dangerous features of mining, at any rate on the Stock Exchange, is the assumption that the neighbour of a rich mine is sure to have the same chances of success. Though in its general application this assumption is dangerous, yet in competent hands it may be perfectly legitimate and helpful. For instance, geologists have evidence that the Rogers lode in East Pool and Agar passes westward into South Crofty ground. They admit that faulting may make its location difficult in depth, and that there is no certainty that when found it will prove to be rich. All they say is that, judging by their knowledge of the conditions and by their experience of ore deposits, particularly in Cornwall, a campaign of prospecting and investigation is fully warranted. It is not, however, of the South Crofty enterprise that we intend to write now. Our object is to draw attention to the discovery of the bonanza at the United Verde Extension copper property at Jerome, Arizona. Here a rich ore-body was discovered by practical business men well acquainted with mining operations, after several eminent geologists had reported unfavourably. We do not know the mental attitude of these geologists, but their case serves to emphasize the reproach sometimes cast at scientific advisers, namely, that they have not the courage of their convictions, and, being jealous of their reputation, assume a non-committal position. The story of the U.V.X. bonanza, as told by Mr. T. A. Rickard in the *Mining and Scientific Press*, will rejoice the hearts of those mining men whose leading maxim is "never abandon a drift until you have driven 20 ft. farther," and will once more strengthen the faith of those who have difficulties in bringing new ventures to fruition or in winning back success to such operations as have been remunerative in the past but are now showing signs of poverty.

The United Verde deposit, of which the U.V.X. is a neighbour, was discovered in 1876 and copper ore was smelted in 1883. Dr. James Douglas examined the property for capitalist friends in 1888, but did not recommend the option to be exercised. Immediately afterward, Senator W. A. Clark, of Montana, purchased the control, and for forty years this remarkable property has been a steady producer. Senator Clark had no use for geologists and discouraged visitors, so that outsiders never obtained any dependable notion of the nature of the ore deposit. Nevertheless many claims were staked on adjoining ground, and much sinking was undertaken with a view to find profitable ore, though with consistent negative results for many years. In 1900 a local surveyor, Mr. J. J. Fisher, found a small fraction of ground hitherto unregistered between the Daisy claim of the United Verde and the March claim belonging to the United Verde Extension Co. On this small area, which was named the Daisy Fraction, a shaft was sunk and copper ore was found, but not in payable quantity. The many vicissitudes and reorganizations of the next few years would take too long to recount here; all that need be said is that the Daisy Fraction was acquired by the U.V.X., the shaft was deepened to 1,200 ft., and many reports were made by engineers and geologists. Finally in the early part of 1916, Mr. James S. Douglas, son of Dr. James Douglas, became interested. He brought the property to the notice of his father, but as the counsel for Phelps, Dodge & Co. considered the title defective Dr. Douglas declined. Subsequently Mr. Douglas and Mr. George E. Tener, of Pittsburgh, took the venture in hand, purchased the control of the company, and subscribed funds for further exploration. A number of their personal friends joined in the subscription of working capital. Mr. Ira B. Joralemon, geologist to the Calumet & Arizona company, made an investigation for Messrs. Douglas and Tener. He was more favourably disposed than the other geologists, who had unceremoniously turned the proposition down; but he hastened to make his own financial position secure by selling the shares he received in part payment of his fee, parting with them at \$6·50, instead of waiting for the discovery, when they went up to \$45. The policy of development was to sink a new shaft known as the Edith, 2,000 ft. to the east of the Daisy.

Cross-cutting on two levels from this shaft toward the Daisy proved disappointing, and more capital had to be subscribed in 1914. The services of another geologist were then requisitioned, and he advised them to abandon the project. But Messrs. Douglas and Tener decided to make another attempt, and they drove southward from the 1,200 ft level at a point a short distance west of the Edith shaft. After driving 400 ft. they intersected a stringer which gradually expanded into a substantial body of 45% ore. Driving was then undertaken on the 1,400 ft. level, and within a short time another ore-body was discovered measuring 440 ft. by 260 ft. This is composed largely of sooty chalcocite of secondary origin and assays anything up to 40% copper. Further development has shown that between the 1,250 ft. and 1,500 ft. levels the amount of ore may be estimated at 2,000,000 tons averaging 15% copper. A veritable bonanza won by old-fashioned perseverance!

To understand the nature of the problem it is desirable to study the geology of the district and the method of occurrence of the copper minerals. The rocks in which the copper is found consist of Pre-Cambrian schists through which diorite has been forced. The sedimentary rocks and the diorite are so much changed by the irruptive action that it is difficult to differentiate always between the two rocks. The primary copper appears to have come up with the diorite intrusion. In later geological ages the schist-diorite has been fractured, and permeated by other igneous flows consisting of quartz-porphyry and felsite, and it is along the intersection of these dykes with the primary ore-bodies that secondary enrichment following erosion from above is supposed to have taken place. Above the schist-diorite are found sedimentary deposits of sandstone and limestone deposited subsequently to the primary ore formation, and over all is a cap of Post-Tertiary basalt. The copper ore would not have been visible at the surface had it not been for a predominating fault formed subsequently to the arrival of the basalt, the result of which was the exposure of the schist-diorite. It was at this exposure that the United Verde deposits were found at the surface. The Daisy and Edith shafts were sunk at a horizon below the United Verde. The Daisy passed through the basalt and limestone, and the Edith through the basalt, limestone, and sandstone, before they reached the schist-diorite. That such sinking should be undertaken may have originally been dictated by nothing more than the general argument founded on vicinity to a known deposit. Nowadays the dropping of the U.V.X. country by the big fault gives an explanation of the chance of finding something valuable in the U.V.X ground. With regard to the actual occurrence of the enriched and primary ores, the petrological relations with the various intruding masses are not yet clearly described, but no doubt explanations will be more liberally contributed now that the deposit has been found and proved.

Precipitation of Gold by Carbon.

The paper presented by Mr. H. R. Edmands at the March meeting of the Institution of Mining and Metallurgy revived the discussion of the action of carbon, whether in the form of charcoal or graphite, in the precipitation of gold from cyanide solutions. That charcoal will throw down gold from chloride solution has been known long enough, and it has been used for this purpose in practical metallurgy, notably at the old chlorination plant at Mount Morgan. But the inter-actions between carbon and cyanide solutions have been less generally understood, though much study has been given to them. In the early days of the cyanide process, charcoal was extensively used in Victoria as a precipitant, as has been recorded in papers by Mr. W. B. Gray and Mr. J. I. Lowles. Otherwise, the carbon reaction has affected the metallurgist only from the point of view of its presence in the ore, or fortuitous access to it, being a nuisance, in that a premature precipitation may be caused by it before the solution arrives at the zinc-boxes. For instance, care has to be exercised that no charcoal or charred wood shall accompany the ore or tailing in its journey to the leaching plant. And, again, the presence of graphite in the ore gives rise to the same trouble, which cannot be entirely obviated owing to carbon in this form being difficultly oxidizable in a preliminary roast. The application of charcoal as a precipitant and the prevention of the deleterious action of graphite are both rendered difficult owing to the fact that the inter-action between the carbon and gold-bearing solution is obscure. It is not at all certain in what form the gold is precipitated. The deposit is not obviously metallic, as is the case with precipitation from chloride. Indeed, when once precipitated on the carbon, the gold cannot be redissolved in cyanide solution, though, as Mr. W. R. Feldtmann has shown, it can be largely brought into solution by sodium sulphide. Nor is it even certain that the carbon of either charcoal or graphite is the actual precipitating agent. In the case of graphite, it appears to be only the graphite in the ore that has this effect, for graphite from other sources introduced into auro-cyanide solutions does not act as a precipitant at all, while, in the case of charcoal, its physical condition is of greater importance than its composition as regards its power to precipitate the gold. In fact the laws of electro-chemistry demonstrate the impossibility of carbon, in itself, acting as a precipitant because it is strongly electro-negative to gold in a cyanide solution. This uncertainty as to the action of carbon has been the cause of the neglect of the application of charcoal in the metallurgy of gold, and revival of interest in it has only arisen owing to the scarcity and high price of zinc.

It is obvious that the theory of the action of charcoal must be elucidated before its application to gold metallurgy can become general, and a number of investigations have recently been made with this object in view. In a paper presented to the Institution of Mining and Metallurgy in 1913, Mr. Morris Green detailed experiments which showed that occluded or adsorbed carbonic oxide caused the precipitation effect. Mr. Green's investigations were not put forward with the idea of urging the use of charcoal at a metallurgical works, but rather with the intention of providing an explanation of the reaction from a purely scientific point of view. In 1915, Mr. W. R. Feldtmann read a paper before the same society recounting the difficulties caused by the presence of graphite in the schistose ore at the Ashanti gold mine, and describing experiments with charcoal and graphite as precipitants. His conclusion was that the gold is precipitated on the charcoal or on the graphitic schist, not as the metal, but as a compound such as carbonyl auro-cyanide, $AuCN, CO(CN)_2$. Subsequent experiment, however, showed that this hypothesis was not tenable. He recognized that the formula involves the consumption of an additional molecule of CN. Seeing that the amount of cyanide actually used in practice is much less than what would be required on this hypothesis, it became clear that the composition of the precipitate could not be that suggested. Mr. Edmands, in his paper, also draws attention to this question, showing that the consumption of cyanide is smaller than the amount called for by the formula, his views thus confirming Mr. Feldtmann's later judgment. Thus the exact nature of the precipitate still remains to be determined.

Mr. Edmands' paper contained a description of the cyanide plant erected at the Yuanmi gold mine, built from designs by himself and Mr. K. Byron Moore. As we mentioned in an article on this plant and process given in our Mining Digest last month, the object was to obviate the cost of and difficulty of obtaining zinc. The auro-cyanide solution is passed through a thin layer of finely ground charcoal, giving only a few seconds of contact, and conducting the precipitation in three stages. The charcoal is made from wood ashes, quenched while hot, washed, and finely ground while wet in a small ball-mill. The grinding is conducted for 18 hours, in order to make the charcoal extremely fine. After passing the solution through three filters of this charcoal, the gold content was reduced from 13s. 6d. per ton to 3·8d. per ton. The cost is about two-thirds of that ruling when zinc dust at 8d. per pound was used. From a metallurgical point of view the process gave satisfaction, and no doubt the results and methods will be closely studied by others. As regards the theory of the process, the comminution of the charcoal has the effect of increasing the available surface, but it is not quite clear whether the adsorbed gases would spread over the additional surfaces exposed in grinding. In fact, the ultimate cause of the charcoal effect is not in any way elucidated by the author. It is true that he gives the results of a great number of tests conducted with the object of finding the best way of preparing the charcoal, his conclusion being that charcoal quenched when red hot and then wet-ground is twenty times as effective as charcoal that has been air-cooled and then dry-crushed. He does not, however, segregate the two effects. Opportunity is thus afforded for further research.

Before leaving this subject we may mention that a further communication on the action of carbon on gold-bearing solutions is expected shortly from Mr. Feldtmann, and that one is also promised by Mr. F. Wartenweiler. We would also say that the discussion at the meeting last month was confined within rather narrow lines, and it is to be hoped that on some future occasion the subject will receive more extended treatment by members. Seeing that charcoal is now having its vogue solely owing to zinc shortage, the discussion should include some statement relating to modern work in connection with the recovery of the zinc and the cyanide. Several metallurgists have been actively engaged in research on these lines, and communications from them would be helpful. It appears to us that the saving of the expensive materials on which reliance can be made constitutes the most important factor of the situation.

REVIEW OF MINING

Introductory.—The great German attack in the West began on March 21, and for a few days the Allies had to retreat before overpowering numbers. The British and French forces are now better organized for the new situation, and American help will be forthcoming on an extensive scale before long. In the mining markets, tin mines have been strong. South Crofty and East Pool have been booming. Some of the bigger producers in other parts of the world have also been in prominence, owing to expectations of special Government deals in connection with increased outputs on the lines of the East Pool arrangement. In South Africa, the success of the Anglo-American company in securing the Rietfontein West lease points to a new source of capital for mines on the Rand. The purchase of the Klippoortje property in the Heidelberg district by the H.E. Proprietary, and the campaign of drilling to be undertaken conjointly with the Rhodesia Exploration Company, are events of prime importance in the history of Far East Rand mining.

Transvaal. — The labour position at the gold mines has improved slightly. After remaining for six months at the low level of 170,000, the figures for natives employed rose to 176,464 at the end of January and 181,066 at the end of February. The March returns had not arrived when we went to press.

Three tenders were received by the Government for the Rietfontein West property, from the Anglo-American Corporation, the Central Mining, and the General Mining & Finance, respectively. The lease has been granted to the first-named. According to the terms of the bid, a company is to be formed with a capital of £1,400,000 in £1 shares to be issued at par, of which 400,000 will be issued forthwith. The Anglo-American Corporation will take 5% commission for guaranteeing the issue. The percentage of royalty payable to the Government will be calculated on the formula

$$65 - \frac{650}{x}$$

where x is the percentage ratio of the net profit to the value of the gold recovered. The ordinary taxation will be paid as well. Two shafts are to be sunk, 6,000 ft. apart, the time occupied being estimated at four years. In the meantime, development is to be conducted from the west haulage shaft on Springs Mines, which is only 450 ft. from the boundary. The two companies are intimately associated.

The H.E. Proprietary Company has acquired from Messrs. Hamilton, Ehrlich, and Turk, members of the board, the northern portion of Farm Klippoortje No. 228, which is situated to the north-east of Heidelberg in the direction of the Nigel group of mines. The area of the property is 3,241 acres. It is believed that the ground is traversed at depth by the Main Reef Series, correlated with the Van Ryn—Modderfontein reefs. The evidence recently provided by the Sub-Nigel is justifiably used as indicating the strong probability of the Klippoortje forming part of the Far East Rand basin. In this matter the company has the advantage of the advice of Mr. E. T. McCarthy. A comprehensive system of boring is to be undertaken conjointly with the Rhodesian Exploration Co., the owners of the adjoining Maraisdrift Farm, and of which Mr. Hamilton is a director. The purchase was effected by the issue of 200,000 fully paid 10s. shares. The deal was unanimously confirmed in general meeting by the shareholders.

There are also other activities to report in the Heidelberg—Nigel district. The Consolidated Gold Fields has acquired a block of shares in the Southern Van Ryn, Mr. W. E. Bleloch's company operating to the north-east of the Sub-Nigel. The Marievale, a dormant Neumann company, owning property adjacent to the Southern Van Ryn, shows signs of returning vitality. Shares have been purchased recently by parties unknown, but whether the object is a market deal or mining operations we are unable to say.

Last month we recorded that difficulties had been raised in the Union Parliament in connection with the proposed modification of the lease of the Government Gold Mining Areas (Modderfontein). Subsequently the matter was thrashed out in a three days debate, during which the objectors threatened to make the dispute one of national importance, even talking of the overthrow of General Botha's Government. Eventually the motion for the modification was carried by 68 votes to 33. The majority was sufficient, but the incident was unpleasant. The proposal has been referred once more to a committee of the House.

The Custodian of Enemy Property in South Africa has reported that there are 26,000 enemy shareholders in gold, coal, diamond, and other mining companies within the Union, and that the value of the assets amounts in the aggregate to £7,500,000. This valuation is vague, for among the assets are mining shares having a *face value* of £4,750,000. Of enemy holdings in individual companies, the largest holdings of interest are those of 298,091 shares out of 970,000 in Geduld, 458,771 out of 1,875,000 in General Mining & Finance, 158,136 out of 550,000 in Rand Selection Corporation, and 66,680 out of 350,000 in New Modderfontein. Enemy interest in De Beers is only £1,402 out of £4,500,000, and only £5,224 out of £80,000 in Premiers. Another small holding is £71,803 out of £7,465,620 in Victoria Falls Power.

Mr. E. A. Wallers, in his annual address as president to the Transvaal Chamber of Mines, classified the mines on the Rand into three groups according as the ore worked is of high, medium, or low grade. He stated that the last named group was producing gold worth £7,000,000 per year without any profit accruing to shareholders. The value of these mines to the community may be gauged by the fact that they employ 6,000 whites and 48,000 natives. The Chamber is making strong representations to the Government with the object of securing concessions to such mines in order that suspension of operations may be avoided. Mr. Wallers also referred to the shortness of explosives owing to the rationing of glycerine, and mentioned that fourteen mines are now using a gun-cotton explosive instead of gelignite.

Last month we recorded that the Messina mine is no longer able to send matte and concentrate to this country owing to shortage of shipping accommodation. The same restriction has been imposed on the Cape Copper Company and the Namaqua Copper Company by the Ministry of Shipping. The operations at the mines of the latter company have been temporarily suspended. The Cape company is continuing to produce and is stocking the products.

Rhodesia. — The output of gold during February was worth £232,023, as compared with £253,807 in January and £289,734 in February a year ago. Thus the decline due to the closing of many small properties owing to adverse war conditions is becoming more accentuated. But part of the decline was caused by a poor return from Cam & Motor owing to water troubles, the figures being £13,129 from 8,325 tons, as compared with £18,915 from 10,782 tons during January. Other outputs in Southern Rhodesia were: Silver 15,599 oz., copper 305 tons, coal 33,095 tons, asbestos 361 tons, chrome ore 5 tons, wolfram 1 ton.

West Africa.—The output of gold during February is reported at £112,865, as compared with £101,863 in January, and £122,602 in December. The figures for Abbontiakoon are more normal than those for January, being £17,289 from 8,870 tons as compared with £12,648 from 9,400 tons. The low returns for January were due, as recorded last month, to the absorption of gold in new tube-mill linings. At the Ashanti Goldfields, the recent fall of ground continues to restrict the tonnage, but some compensation as regards output of gold is provided by the treatment of ore of more than average grade.

Nigeria.—Sir Abe Bailey, after creating a sensation in Rhodesia by returning to mining speculation, has more recently devoted attention to Nigeria. His new company, the Anglo-American Rhodesian Exploration Co., has already acquired a controlling interest in the Kwall Tin Fields of Nigeria, Ltd.

India.—As recorded last month, the grade of the ore mined at the Mysore is being reduced owing to the poor results of recent development. The yield per ton for January and February averaged 50s. as against 55s. last year. Included in these returns is about 2s. derived from old tailings. As reported on another page, the reserve stands at 939,000 tons as compared with 1,019,000 tons a year ago. Exploration in Ribblesdale's section is rather more hopeful, for after several hundred feet of disappointing lode, the gold content below the 53rd level has again reached a profitable figure. In McTaggart's section, though the general results have not been good, some rich ore is still being found.

Australasia.—As recorded in November, the Great Boulder Perseverance went into liquidation, owing to the cost of mining and treating the remaining ore being greater than the recoverable content. It was decided to extract all the rich ore available and to close-down as soon as possible. It is now announced that, by the advice of Mr. E. Devonport Cleland, who is in charge of the mine, the breaking of high-grade ore has been continued, and concurrently the reserve of broken ore has been drawn, altogether providing at least 16,000 tons per month. When liquidation was decided on, the broken ore amounted to 220,000 tons, and most of this is expected to yield a profit. In spite of scarcity of skilled miners and of the legal sanction for shorter hours, the operations during the last few months have resulted in a profit, so that eventually there may be a surplus distributable among shareholders.

The taxing authorities have granted the

Fremantle Trading Company a statutory 14% as profit rate in connection with the incidence of the excess profits tax. This company owns lead mines in the Northampton district of West Australia and a smelter at Fremantle, the control being in the same hands as the Golden Horse-Shoe. During the year covered by the last report, 2,956 tons of lead concentrate was produced at the Baddera mine from 20,622 tons of ore, and 3,442 tons at the Narra Tarra from 24,734 tons. This, together with 620 tons of purchased ore, gave a yield of 4,908 tons of lead. The profit was £5,835, and £5,610 was distributed as dividend, being at the rate of 10%. Recently another mine, the Wheal Ellen, has been reopened, and gives a fair promise.

The output of minerals in Tasmania during 1917 is reported as follows:

		Quantity	Value £
Gold	oz.	14,028	59,588
Silver-lead	tons	11,216	174,541
Blister copper	tons	5,773	855,108
Copper and copper ore	tons	541	4,804
Tin	tons	2,573	393,586
Coal	tons	63,856	38,638
Wolfram	tons	169	27,595
Bismuth	tons	4	915
Iron pyrite	tons	9,477	8,942
Asbestos	tons	276	276
Scheelite	tons	59	10,452
Zinc	tons	48	2,008
Osmiridium	oz.	322	4,600

Molybdenite deposits in Victoria are receiving attention once more. In the Beechworth district, at Everton, the granite has been known for many years to contain molybdenite. A Melbourne syndicate is now actively engaged in prospecting and development. At Mount Moliagul, 40 miles west from Bendigo and 110 miles north-west of Melbourne, a local syndicate has been working on a deposit, and the results are so good that a company called the Mount Moliagul Molybdenite Co. has been formed. Mr. J. A. Jensen, Minister of Customs, is the chairman, and the capital is £60,000.

The Queensland Government has decided to hasten the development of the coal deposits in the Dawson district, on the Dawson River, 50 miles south-west of Mount Morgan. These deposits belong to the Permo-Carboniferous age, and the seam as far as developed is about 9ft. thick. The Mount Morgan has an interest in the deposits and draws a supply from them. The Government is to conduct an extensive drilling campaign, and eventually to establish a state coal mine.

Cornwall.—In his speech at the South Crofty meeting, to which reference is made elsewhere in this issue, Mr. Josiah Paull stated that the trades unions have made big strides in the county during the year, and that a large proportion of the workers, including the miners, are now members of one or other of the several unions. South Crofty has endeavoured to interest the miners in their work by offering additional monthly wages when the mine is making a profit. The condition for sharing such extra remuneration is that each employee shall work for 23 out of 24 days per four weeks. Out of 500 or so employees, 98% are accepting this condition.

At the South Crofty meeting, Mr. Francis Allen, the chairman, referred to a possible new venture in which the funds of the company might be invested. It is now announced that the business consists of the purchase of the Castle-an-Dinas property, situated to the north of Tregoss Moor, midway between Roche and St. Columb. The property was worked formerly for tin, but wolfram is now the mineral in view.

We refer in our editorial columns to the meeting of South Crofty shareholders. The meeting of East Pool & Agar has also been held during the past month. A net profit of £59,651 is the result of last year's working of these mines, and is a foretaste of what may be expected for the current year with a doubled mineral output. Of this profit, £24,060 is distributed in dividend (equal to 1s. 3d. per 5s. share), £20,000 is capitalized, and the balance carried forward. The capital of the company is to be increased by £20,000 to £120,000, and these new shares are to be distributed free to the shareholders in the proportion of one fully paid share for every five shares now held, so that in effect this is the distribution of a very handsome bonus, seeing that the shares have a market value of 31s. to 32s. per share. The figures for the output are given elsewhere in this issue. Of the ore milled, only about one-third was broken from the Rogers lode. The total working cost, including depreciation, was 30s. 9·7d. per ton. The ratio of development was 1 ft. to every 13 tons milled, and in addition 651 ft. of diamond-drilling was carried out. Orders have been placed for an electrically-driven pumping plant, which, when installed, will supplement the Agar pump and thus safeguard against the suspension of underground operations through a breakdown of the latter. The recent purchase of the mineral rights of the adjoining abandoned setts of Carn Brea, Tehidy, and Wheal Union, coupled with the acquirement of licences on the Great South Tolgus and the South Tolgus mines, makes the company's property a very large and compact one. The Carn Brea pumping engine has also been purchased. There is a large amount of ore in the Carn Brea sett that would pay to mill at present prices of tin and other minerals. Local opinion favours the testing of the ground between the existing workings at Carn Brea and those of East Pool.

Canada.—Herewith we give official statistics of metal mineral production during 1917, as prepared by Mr. John McLeish.

Metallic.		
Antimony, ore (exports)	Tons	774
Cobalt, metallic contained in oxide, etc.	Lb.	1.089,134
Copper	"	108,860,358
Gold	Oz.	747,366
Iron, pig from Canadian ore	Tons	46,022
Iron ore sold for export	"	169,192
Lead	Lb.	32,072,269
Molybdenite	"	271,530
Nickel	"	84,470,970
Platinum	Oz.	49½
Silver	"	22,150,680
Zinc	Lb.	31,227,351
Non-Metallic.		
Arsenic	Value in Dollars	709,937
Asbestos	Tons	134,322
Asbestic	"	9,596
Barytes	"	958
Chromite	"	23,327
Coal	"	14,015,588
Fluorspar	"	4,249
Graphite	"	3,714
Magnesite	"	58,090
Manganese	"	158
Mica	Value in Dollars	350,732
Natural gas	1,000 cu. ft.	26,465,686
Petroleum	Brls.	205,332
Pyrites	Tons	403,243
Salt	"	138,909
Talc	"	15,812

United States.—The control of the silver market by the United States Government has just been arranged. It is stated that a bill is to be introduced into Congress authorizing the melting and sale of 250 million silver dollars out of 460 million held against silver certificates. This released silver will be available for export to Europe, India, and to countries on a silver basis, and the sale will relieve for a time the stringency of demand. At the same time the Government is undertaking to purchase the whole of the United States output at $1 per ounce, in order to replace the silver sold.

The Tomboy Gold Mines, in Colorado, were worked at practically no profit during January and February. This condition was caused partly by increased costs and partly by lack of labour, the latter influence making it necessary to use poor ore that was easier to mine. It is believed that conditions have once more become normal and that profits are being made.

The appeal by Butte & Superior against Judge Bourquin's decision in favour of Minerals Separation was heard at San Francisco last month, and judgment was reserved. It will be remembered that the judge held the addition of unnecessary oil just for the purpose of bringing the amount used to a proportion over 1%, to be merely a clumsy and inefficient device to defeat the judgment of the Supreme Court, and as such had no standing in law.

Siam.—The Renong Dredging Company announces that owing to the difficulties in obtaining spare parts it has been found necessary to put No. 3 dredge out of commission, so that for a time there will only be two dredges at work.

We draw attention to an article elsewhere in this issue describing an electrically driven Bucyrus bucket-dredge recently erected at Pong, on the Kopah river, Siam. The article gives particulars also of another Bucyrus dredge now working in Pahang.

China.—We have referred several times during the last two or three years to the mineral resources of Sze-chuan, and we have also mentioned the many railway projects for the improvement in means of communication throughout China undertaken by the American firm, Siems & Carey. This firm now announces that the surveyors have discovered a possible railway route for approaching Sze-chuan from the east. The route follows the Han river, from its junction with the Yangtze at Hankow, up as far as Tze-yang. Thence it passes up the Jen-ho, and across the Tapaling mountains, to the head of the Tung river, and on to Cheng-tu, the capital. This line of communication with the industrial and manufacturing centre of Hankow will greatly help the mineral development of Sze-chuan.

Spain.—The Rio Tinto Company publishes no information with regard to output and policy, under present war conditions. Thus the report for 1917 merely records that the profit for the year was £2,004,990, out of which £81,250 has been paid as 5% dividend on the preference shares, and £1,687,500 on the ordinary shares, the rate being 90%. For 1916, the ordinary dividend was at the rate of 95%.

The Cordoba Copper Co. announces that owing to continued poor results of development the workings on the main Cerro Muriano lode are to be abandoned. Sinking and development are to be conducted vigorously on the northern sections of the property, where the Calavera, Lorenzo, and Excelsior lodes give promising indications. It is expected that the cost can be defrayed entirely out of income.

THE ALLUVIAL TIN PROPERTIES

BELONGING TO THE

NORTHERN NIGERIA (BAUCHI) TIN MINES, LTD.

By A. R. CANNING, M.Inst.M.M.

THE property of the Northern Nigeria (Bauchi) Tin Mines, Ltd., as at present owned, is the pick from 92 square miles over which, for some years, the company held exclusive prospecting licences. The selected ground is held under leases for 21 years. Most of these leases follow the course of small rivers or streams, and generally have a width of 400 yards. There are many of these streams, and the length of ground covered is not far short of 50 miles. It will thus be seen that the holdings of the company are extensive, and as no leases are acquired without first proof of the existence of tin, it follows that the life of the company has to a certain extent a guarantee from the area of its holdings. There are eight camps of varying importance scattered over the property, and from these centres the several tin deposits are worked.

Generally speaking the tin is found in the river or stream beds, or under the containing banks, but within the past two years by far the most important deposits discovered have been at considerable distances away from the present rivers. It is to be noted that tin in Northern Nigeria, when found in the banks or away from the stream, lies in a gravel wash on or near the granite bedrock and covered by practically barren overburden. In this it differs from tin deposits in Tasmania and certain other localities where the tin is often carried more or less evenly from the grass roots downward. For the most part the overlying ground is composed of a red soil or clay, which, during the long dry season, becomes excessively hard. Not infrequently the overburden may consist of laterite. Sometimes there are several layers of tin above the bottom layer, with from one to a few feet of gravel or clay separating each layer. The tin is generally unaccompanied by other minerals, and there is little difficulty in obtaining a concentrate containing 70 to 74% of tin metal.

The plan (Fig. 1) will show that, roughly speaking, the streams flow from east to west. The eastern boundary of the property runs along the highest edge of the Bauchi plateau, and it is near this line that the streams take their rise. It will be seen that the properties are quite close to the town of Bukuru. The country here is open grass country broken by granite hills and kopjes, and in most cases tin is fed into the stream beds from hills lying but a short distance away. Although there is a possible exception or two, it is correct to say that no lode of value has as yet been found, and that the tin finding its way into the streams is disseminated very finely through the granite of certain of these hills, or probably it would be more exact to say exists in the lines of cleavage in the rock. It is noticeable on this property, and probably throughout the plateau, that the kopjes, where the granite shows irregular fracturing, are more likely to shed tin than those weathering into rounded boulders. The fracturing is no doubt due to minute seams of quartz which constitute the carrier of the tin, but it is seldom that evidence of a definite character can be found.

To describe the methods of working, it will be well to divide the course of these streams into three sections: Upper, Middle, and Lower. In each the conditions vary, and consequently a different system of working obtains.

In the UPPER sections the stream beds are for the most part laid bare by the floods during the rainy seasons, and only in the natural riffles or pools formed by the varying hardness of the rock is the tin deposited. The bars formed by the harder rock are very wide, and the system of bringing up a tail-race to work these stream beds is often impracticable on account of the relative cost. Small flats intervene between these bar occurrences, and tin is deposited under depths up to 10 ft. of soil. Owing to the smallness of these areas it is often not worth while to work the ground in the Upper sections of the stream under white supervision, and hence there is in vogue the practice of allowing native tributers to work these sections for tin and sell it to the company. This practice began in the early days of the tinfield, and most companies still keep it up. The tin is won by calabashing the deposit in the stream bed or, where the banks are being worked, after the native has removed the overburden by digging down to the rock below. The evil of this system is two-fold; firstly, that the native loses a great deal of tin and works without any method, thus leaving many unworked pillars; secondly, that there is a risk that where a higher price is paid by another company or individual not too far distant, he will sell his tin there rather than to the company from whose ground it has been won; this might go on for a long time quite unsuspected by the companies concerned. Again, the tributer has always to be watched so that he does not get on ground where he is not allowed, and his hours of work, except in camps where conditions are favourable to supervision, are short, and harmful to day labour. On the other hand much tin has been won that would not be worth getting under white supervision. And further, it is incontestable that tributers are excellent prospectors, and valuable deposits have been found where they would not otherwise have been looked for. Nevertheless the days of the native tributer are numbered, and this company hopes shortly to eliminate him altogether. He has been a great aid during the past few years in helping to maintain the output while the heavy prospecting has been going on, and for that reason has been encouraged and assisted. The price paid over the plateau to the native tributer for clean concentrate has ranged from 1d. to 4d. per lb., this company paying from 1d. to 2½d.

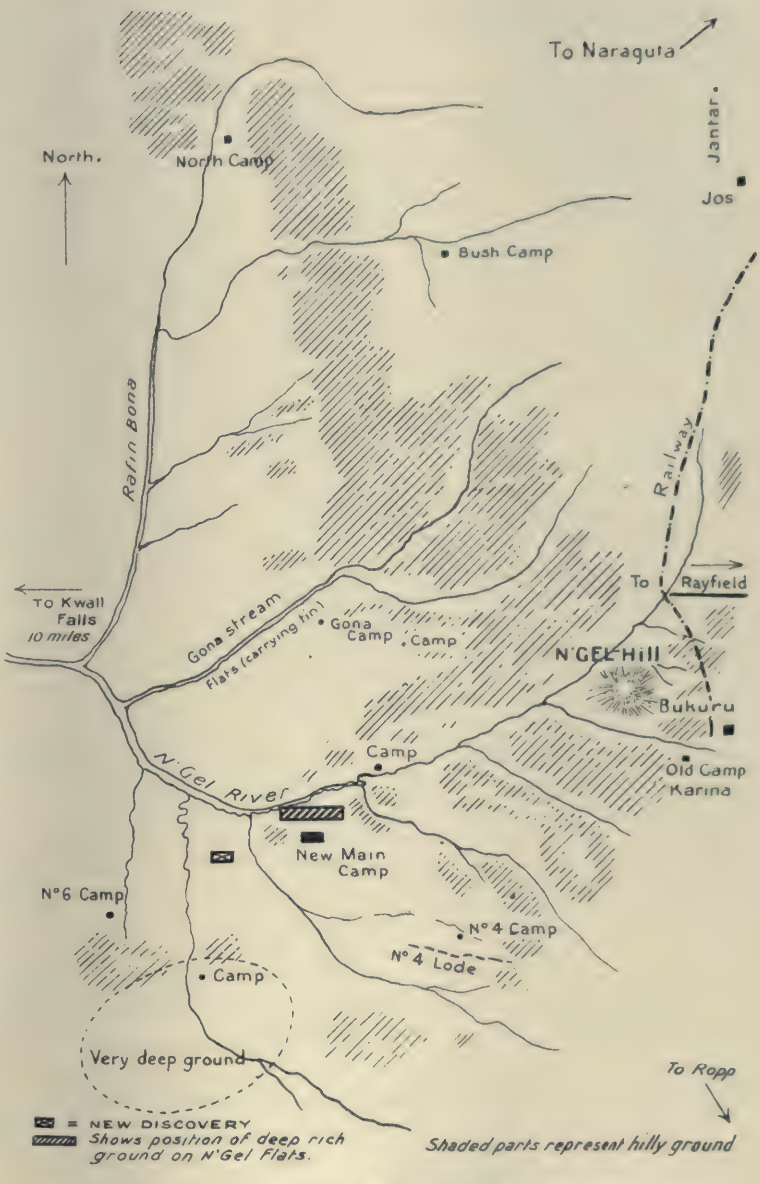

FIG. 1.—GENERAL MAP OF THE PROPERTIES.

Bracketed with the Upper sections must be counted a lode, which, although not payable as a mining proposition, has shed tin which has been most useful in helping to maintain output. This lode runs for some 2,000 ft., and is composed of quartz varying from 10 to 20 in. wide. Tin occurs in short ribbons up to 2 in. wide but of no length, and the whole is unpayable. Toward one end of the lode there is more wolfram than tin. The detrital matter shed from this reef, however, is valuable and spread over a considerable area. The ground falls away gently from the outcrop, and the soil overlying the rock is shallow, varying from 1 to 5 ft. Water is brought in about 1½ miles from a dam, and ground-sluicing is carried on for several months of the year. In this way fully 150 tons of concentrate has been won at low cost. It is the tin carried away from this area into deep ground that forms the latest discovery made by the engineers of the company, and its occurrence is set down later on.

In spite of the fact that these rich Upper reaches of the streams have in the past supplied probably half of the tin won since the company started operations, they will still contribute appreciably toward the output for some time to come.

The MIDDLE section comprises the deposits after the streams have dropped down from the higher ground. Generally they have then a mile or two of course before a further series of falls lands them on to the lower flats. Along this second section tin is found at a depth of 10 to 30 ft., and occasionally more. Here two systems of work are successfully employed to recover the tin. The first is the employment of water during the rainy seasons, and for a short time afterward while the streams are full, to strip off the barren overburden overlying the tin, which latter is then recovered during the remainder of the year, either by ground-sluicing or by carrying-out and boxing. The second method is only undertaken where the ground is waterlogged or where but a few feet at the top can be removed by stripping, owing to the wide bars of hard rock holding back the water. It consists in the employment of centrifugal gravel pumps to lift the tin-containing ground up a height of 30 to 40 ft. into sluice-boxes, where the tin is concentrated and recovered. The banks are broken down and disintegrated with monitors, and the soil, gravel, and water flow through races cut in the soft bedrock to a sump from which the pump picks them up. The motive power for these pumps is supplied by an oil engine, crude oil being used; before the rise in the price of oil the cost in fuel worked out at about 2½d. per yard of ground lifted. By means of dams on the higher ground, races, and pipe-lines, the necessary water and pressure for the monitors is found. Both in stripping overburden and in the working of these gravel pumps, this company, with many others, has benefited greatly by the employment of Australians. Given the right sort of man, and there are many of them, you cannot wish for better judgment than they show in laying out their races for stripping, or in working a difficult paddock with a nozzle and a gravel pump. I should like here to make acknowledgment to the great assistance many such Australians have been to this company.

The two principal streams on the property are the N'Gel and the Gona. The latter presents rather an unusual feature (see Fig. 2) just before it reaches the lower flats. Here an old bed containing huge boulders of granite exists, and the tin is found in layers or clinging round the boulders up to a level of 6 to 8 ft. above the bedrock. Above this again is hard red sandy clay to a height of 50 ft. above the rock. For some time there was a considerable difficulty in bringing water on to the top of this ground, and the method adopted to remove the overburden was the use of black powder, the broken ground being then swept away by water running in a race at the base of the cliff, but above the pay ground. The use of black

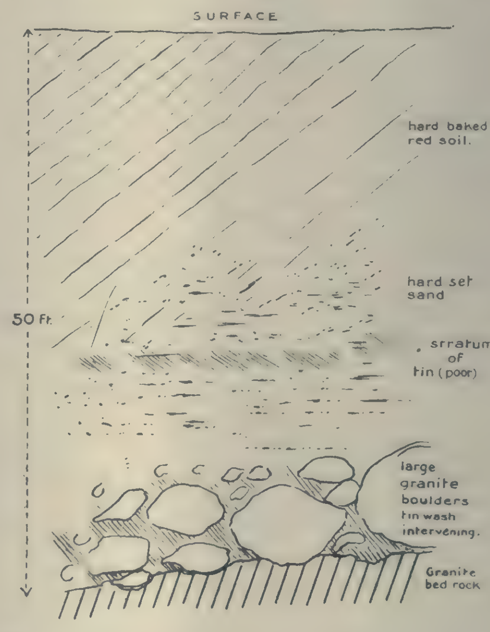

Fig. 2. Section of ground on the Gona River, where black powder was used for removing hard overburden before water was available to break down the ground.

powder to deal with very hard surface ground has been frequent on this property, either in removing overburden, or in quarrying hard clay soil with which to build dams, and has been most successful while powder was obtainable. I think this is the only company that has adopted this labour-saving method in Nigeria.

No two streams are alike and the working has to be adapted to suit the conditions, but the foregoing indicates a few of the methods resorted to. There are many dams over the property, many miles of leats, and frequent 12 in. or 15 in. pipe-lines, the latter aggregating some 5,000 yards. It is this Middle section that must play the chief part in maintaining the output during the next two or three years, that is to say, until the deep ground in the lower flats can be developed and come into line as a producer.

Lastly, we reach the LOWER section. For a long time the tin was so hidden in this section that doubts were many as to whether the tin carried down so far, or whether it was not more probable that the catchments higher up had collected all that had been shed from the hills. Six years ago the sandy river bed, which meanders for some miles between its banks, had been bored, but although there were over a hundred holes put down no system was followed. A few good results were obtained, and there was the chance that regular lines of bores might show some definite gutter. Three years ago therefore eight lines of bore-holes were sunk a few hundred feet from one another. In each line the bore-holes were only 20 ft. apart, and twenty or more were sunk in each line. The results were most disappointing, for only 467 tons, obtainable from an average of 1·8 lb. per cubic yard over a depth of 36 ft., were located. I then instructed that the flats lying back from the high banks should be bored and, following these directions, Mr. Hippisley, whom I had left in charge, bored across a surface depression, and almost at once located tin 1,000 ft. away from the present river bed. The season being late, not much could be done that year. The following season the drilling, although it totalled over 16,000 ft., had to be carried on over many square miles of expiring Exclusive Prospecting Licences, in order that any ground of value should be taken up by lease before these rights lapsed. The dry season of 1916–17, however, supplied the opportunity. The system adopted to prove these entensive flats was marked out by Mr. T. J. Andrews, the present manager, when I was on leave, and took the form of a base line running east to west down about a mile of their length, with offsets north and south from this every 100 ft. Along these offsets, and at their point of departure from the base line, bore-holes were put down again at every 100 ft., so that a chess-board appearance resulted. As stated in the last annual report of the company, a length of 3,400 ft., and varying from 200 to 700 ft. wide, was proved payable. The depth varied from 40 to 80 ft., and the estimate of yardage and values gave 2,587,000 yards, containing 3·15 lb. tin oxide (70%) per yard, equivalent to 3,642 tons of black tin. The value of this tin at the price prevailing when drilling ceased (£240 a ton) was £625,000, a value that has since appreciated; surely not a bad result for seven months work. The position of this deposit is roughly shown in Fig. 3.

After this 3,400 ft., the season being late, we jumped 500 ft. between each line, but extended the lines laterally, since the country opens out, and the hills, which enclosed at some distance the upper portions of the flats, had died down. Only occasional values were met and these were below 2 lb., but it is possible that the channel has narrowed and the

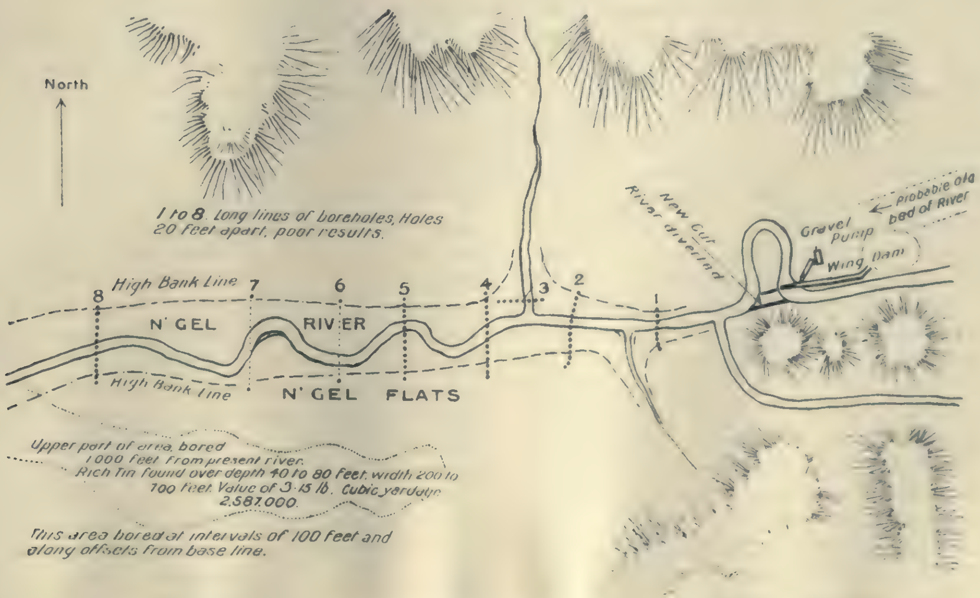

FIG. 3.—SKETCH SHOWING N'GEL RIVER DEPOSITS, AFTER THE STREAM LEAVES HILLY COUNTRY.

100 ft. apart bores failed to locate the continuation, which, however, is without doubt poorer as the hills are left behind. The depth here is less, only thirty to forty feet. In boring we found an excellent indicator in the form of a small wash, with pebbles up to 1½ in.; even where we drew blank this indicator pointed to the pay-channel being near there, and values were picked up again in the next hole. At the upper end of the ground the highest values included bores giving 8, 10, 14, and 18 lb. per yard over a depth of 60 to 70 ft. In certain places there were two layers of tin separated by 20 ft. or so of clay, but the upper, corresponding to the main deposit, was the much richer, and is the only one taken into account in estimating reserves. Fig. 4 shows these two tin layers.

Another deposit must also be referred to, for, although it has not yet been defined, the data so far available prove it to be the deepest tin found in Nigeria. Apart from the depth, another remarkable feature connected with this deposit is that the rich tin lies in a wash above and not below many feet of quartz sand, which has to be bored through before bedrock is reached. This old stream bed was found nearly 400 yards away from the existing stream, which later had proved practically valueless by boring. In the first hole to carry tin, values were first struck at 90 ft., and there the hole bottomed; the succeeding bores did not reach rock till 110, 113, 131, and 117 ft., but the tin in these cases also ranged round about a depth of 90 ft.; two holes were exceedingly rich, 6 and 11 lb. per cubic yard over the whole depth, but others were poor, so that for the present it is safest to consider these as abnormal. The white angular quartz sand below this level carried very low values. In June last the rainy season put a stop to prospecting here, but more will be learned of this deposit during the present dry season. From this point of discovery up to the place in the present stream bed where values became erratic, the distance approximates 1,000 yards, so that there is good hope that further reserves will be opened up. In this case about 40 ft. of barren overburden can be sluiced off by bringing water over the top, and probably at a cost not exceeding 1½d. per yard. One of these deep bores is shown in Fig. 5.

The above describes some of the work done by prospecting. Speaking generally these campaigns cover the dry season, that is to say, about six months. During the dry season of 1916–17 no less than 18,732 ft. was drilled, and the total during the past three seasons reaches 50,000 ft. For depths of over 60 ft. a Keystone power-drill is generally used. For less depth bores have been put down by means of the Banca, the Empire, and the Alluvial, six to ten drills being kept going throughout the season. In this way well over a million pounds worth of tin has been located. It must not be supposed that this work was all straight going, for the ground prospected has ranged all over this extensive property, and on one occasion we drew blanks for nearly three months; these deposits had all to be found and they took a great deal of looking for. Deep boring in swampy ground presents difficulties to be overcome, and the drawing of the casing after passing through 20 ft. of bad clay at considerable depth was slow work, but only about 30 ft. of such casing has ever been lost. Great care and many visits attended the tracing of tin when found, but results have amply rewarded the time and expenditure thus laid out.

I have only touched on a small portion of the work done, but it is necessary now to pass on to the question of working these deep deposits.

The cost of lifting the overburden and finally the tin from such considerable depth at a low cost engaged attention when the deep ground had been proved beyond all doubt. The property lies near the terminal of the Bauchi Light Railway, which joins the main line 144 miles distant at Zaria; thus it is situated at 768 miles from the port of Lagos. To get coal on the property would cost not less than £5 per ton, and, at pre-war prices, crude oil about £15 a ton. Upward of 1,000 h.p. will be wanted to adequately work this property. Thus using either fuel the annual bill will be in the neighbourhood of £30,000, a large figure when running on over several years. Under these circumstances attention was given to the Kwall Falls to see if they would afford a solution to this important consideration. These falls lie less than 15 miles distant, where the river N'Gel drops 800 ft. over the edge of the plateau. For roughly eight months in the year the required water, 11,500 gallons per minute, is available. To secure running throughout the year a storage dam will be necessary. There is a very remarkable site for this latter, subject to its being confirmed by a civil engineer who has been sent out to the property by the board and whose report may be shortly expected. The river runs through a short valley with steep sides rising uniformly to 70 ft. above the water; further up stream the valley opens out into a basin. The projected site at the lower end of the

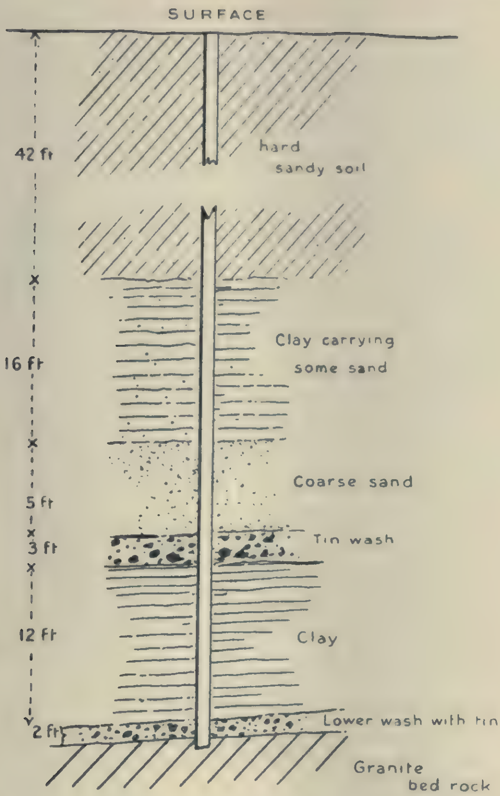

FIG. 4. — SECTION THROUGH 80 FT. BORE-HOLE WHERE TWO LAYERS OF TIN WASH ARE MET.
This ground has not been fully prospected, and no tin from the lower thinner wash is taken into the reserves.

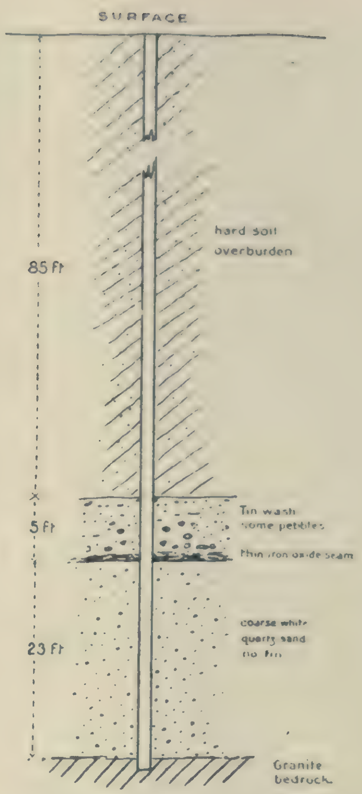

FIG. 5.—SECTION THROUGH BORE-HOLE AT NEW FIND.
Value 11·6 lb. per cu. yd. over 113 ft. No tin below 90 ft. About 40 ft. of overburden can be removed by stripping with water.

valley will only require a wall 500 ft. long at the top, 250 ft. at the base, and a height of 60 ft. A natural by-pass for big floods is present a little way up stream through a saddle in the hills and at the required height. The water impounded would be in the neighbourhood of 400 million gallons, which, after allowing amply for evaporation, should more than suffice. The smaller scheme, depending on an eight months run and without impounding water, presents no difficulties other than securing pipe-lines down the steep hill-sides; these pipe-lines would be fed by a race of about two miles, and the project can be at once accepted as practicable.

The larger scheme involving the dam requires the confirmation of the expert's opinion, based on a closer study of the ground and a greater experience of this class of work than the writer has been able to give. Probably two pipes would be used to convey the water down to the power house. The power can be carried on wires across open country after rising out of the gorge. The motors at the other end would work gravel pumps, and probably the system adopted would be to remove 30 to 50 ft., dependent on the depth of the ground, of barren overburden with one set of pumps, thus giving the lower set of pumps, bringing up the tin, less work to do to compensate for the greater height to be lifted.

It will thus be seen from this outline sketch that the Kwall Falls is an acquisition worth obtaining. It took the writer 16 months to secure this concesssion, involving among other things following the Governor to England and out again, and protracted negotiations to ensure essential financial and other points in the agreement. It was worth while, however, for the work of securing this company's future was not complete with the finding of the tin, for the means to work such deep ground economically had also to be determined. Somewhat more power than is actually needed is obtained by this scheme. As to the question of capital to carry out the installation as outlined, this must be affected largely by prices ruling after the war and also on the report now to be made, but it is safe to say that it will be far less than, indeed it is unlikely to exceed half, the cost of the installation and of the fuel required to work out the property should any other form of generating power be adopted. The profits will be very much higher and an important asset will afterward remain in the hands of the company. There are other benefits, and these will no doubt be pointed out when the directors are in a position to present the project.

From the foregoing sketch of the company's holdings it will be fully appreciated that it is a property with a future and full of interesting problems. There should be no difficulty in keeping up the present output which, having regard to dividends, is entirely a satisfactory one, until a power plant is completed, when returns should not fall short of 1,000 tons per year. As output moves up so costs will move down. The nature of the deposits and the methods of prospecting and working do not differ in principle from those found in other countries, but the conditions are different and appliances have to be adopted to suit these.

The general question as to whether gravel pumps or bucket dredges are best suited to deal with the conditions met in Nigeria will always be, as in other countries, a source of controversy. To have predilections in favour of one or the other, without first obtaining full data as to the deposit that it is wished to work, is to court failure. Whether the bedrock is hard or soft; whether the tin is evenly distributed, or contained in one or more rich layers; whether the clay can be stripped before the tin need be brought up; whether rich deposits are not tucked away under large boulders and thereby rendered inaccessible to the bucket dredge, or whether the loss from such a condition is not more than compensated by other gains, are all matters that can only be determined after the fullest knowledge has been gained by boring. The conditions prevailing on the Middle sections of the Bauchi property have shown that, owing to the irregularity of the stream bed and to the large boulders under which much of the best tin is hidden, suction gravel pumps and the free use of monitors alone could have been worked economically. Such a system also discovers much good ground not found by the previous boring, and at the same time permits barren sections to be left unworked. The flats in the Lower sections of this property present very different conditions, and while gravel pumps may again be adopted, the decision would be arrived at for entirely different reasons from those governing their employment in the Middle sections.

The round of the year brings a dry and wet season. During the former the Harmattan wind, bringing with it a very fine dust, is rather a nuisance; and during the last two months before rain falls the heat is very trying. The dry season lasts roughly from early October until the end of March, though an isolated but troublesome storm, since it upsets the dry season methods of work, generally comes before this. The early wet season takes the form of a succession of violent and dangerous thunderstorms, with fine intervals of a week or more. This is the difficult time to maintain output, for no settled method of work can be followed, the streams not yet being set permanently running. The real wet weather seldom lasts more than three months, but then it is real wet. The ground is sodden, the rivers rise rapidly and cut off communication between the camps on the property, and elsewhere. As to the climate generally, the sun is undoubtedly dangerous, and carelessness leads to "a touch of sun" and to occasional blackwater fever (the latter often fatal), but otherwise the temperature is pleasant and not unlike Rhodesia, the altitude being also approximately the same, 3,500 to 4,500 ft. The nights are always cool.

The property has now many passable roads and bridges, and the work of supervision is far easier than it was a few years ago. Each member of the staff of white men, about ten to fourteen, is provided with a horse to get round his work, and about 1,200 natives are generally employed. A few years ago there were two or three times this number of natives, but 1,200 is found sufficient.

There is little doubt that the present satisfactory position is due to a steady continuity of the same policy, a condition that did not obtain prior to 1913. No manager, even when he overlaps his predecessor several months and carries on a settled programme, can hope to know his ground with any real intimacy under two years. The staff under him are continually changing so that he cannot rely on another man's knowledge of a distant part of the ground; he must know all about it himself. This intimate knowledge alone has led to the finding of these valuable deposits on this property, and I am sure that others, though probably not so large, will be found. For the same reason it is advisable to re-engage as many of the staff as possible for second and third tours. On returning they fall at once into their work and their previous knowledge is of great use to the manager. A new man begins to really know the property but a few months before his agreement is up. The company stands well with its employees, and for this reason they have been fortunate in getting many excellent assistants to re-engage; there can be little doubt that this has been a large factor in their success.

No description of the country and work would be complete without some reference to the natives with whom the tin-mining community on the Bauchi Plateau has to deal. Those employed to work these deposits come from long distances and are only sojourners on the plateau. The real native, the Pagan, living in large villages generally set among rugged kopjes, are pure agriculturists, and are so busy with their own work that they very rarely can be secured for tin mining, nor are they in any way suitable for most of the work. They do their own iron smelting and are in many ways a very interesting study. Those Pagans living at N'Gel are a fine type, absolutely innocent of clothing, and, though a few years ago they were cannibals, very friendly relations are maintained. The company's main camp was set in the heart of their village until a year ago, when the New Main Camp, situated on high ground near the deep tin deposit of Lower N'Gel, was built. A distinct race are the Filani, who own the innumerable herds of cattle which graze over the country. The Filani frequenting the plateau are a nomadic people, moving about with their cattle, and not many are employed by the tin companies. The natives employed on the mining properties are Hausas, or other races from off the plateau. They vary greatly in their physique and capabilities both for work and for driving the white man crazy. Shortage of labour is more or less chronic on some of the properties and on none is it unknown. The presence of a good market is the biggest factor in securing ample labour. The pay for unskilled labour is 9d. per day. The skilled labour is from the South. Some excellent carpenters, fitters, and other trades, come up from the Niger Provinces, but for every good tradesman there are ten bad ones, and the work of the white staff is not made easier by the difficulty in securing sufficient trustworthy natives.

Such are the prospects, the mode of work, and something of the conditions of life on the properties of the Northern Nigerian (Bauchi) Tin Mines, Ltd., and in many respects they are similar to those found on or associated with other tin-mining enterprises on the Bauchi Plateau.

TIN-DREDGING IN THE EAST

By C. T. NICOLSON.

The author gives particulars of electrically-driven dredges made in America for companies operating in Siam and Pahang.

A YEAR or more ago the Magazine published a series of articles by Mr. Harry D. Griffiths on "Bucket-Dredging in the Federated Malay States." With the object of supplementing this information, and of giving details of American practice in the construction of tin-dredges, I am giving herewith particulars of dredges built by the Bucyrus Company, of Milwaukee, for the Bentong Tin Co., registered in Australia, and the East Asiatic Co., registered in Denmark. Both these dredges are electrically driven, and are, in fact, the first bucket-dredges to be driven in this way in Malaya or Siam.

THE BENTONG DREDGE. — This dredge was put in operation on May 10, 1917. The property is in the State of Pahang, and is about 50 miles from Kuala Lumpur. The ground worked differs from that treated by other tin-dredges in the Malay States or Siam, as there is a large quantity of coarse gravel present, and it might be compared with the dredging ground at Oroville, California. The plant was built from designs submitted by Mr. S. L. G. Knox, formerly chief engineer of the Bucyrus Company, who acted in the capacity of consulting engineer for the Bentong Tin company. It was shipped to Port Swettenham from San Francisco on a steamer specially purchased for the purpose by the Bentong company. Afterward the ship was sold to profit. The plant was moved by rail from Port Swettenham to Kuala Lumpur, and from that point to the mine it was transported by motor lorries.

The company has its own hydro-electric plant for generating power, using 3-phase, 60 cycle, 2,000 volt motors. The dredge has a close-connected chain of buckets, of 7 cu. ft. capacity, and is capable of digging to a depth of 25 ft. below the water on which it floats. To hold the dredge up to the working face, structural-steel spuds are used. These are 48 ft. long, and 30 in. deep and 24 in. wide in the cross section. However, a head line is also provided in case it should be found necessary at any time to use this method of operating. This line is also of service in making heavy repairs or renewals to the bucket line, etc. The method of using the spuds differs from the usual practice. In California, they are placed directly back of the stern; in this case they are placed about 20 ft. from the stern, and pass through an opening in the pontoon, the object being to remove the weight of the spuds from the extreme stern of the dredge where the load is greatest, due to the accumulation of concentrate in the tin-saving tables, which extend beyond the stern of the dredge about 25 ft. These tables are made in two decks with a space of 6 ft. between, and have a total area of over 5,500 square feet. The steel pontoon is 125 ft. long, 44 ft. wide, and 8 ft. deep, with twelve water-tight compartments. These are made up by heavy longitudinal and transverse bulk-heads that stiffen the pontoon. In addition to the above, the well-hole plate extends the full length of the pontoon between decks. The upper tumbler and the main drive are supported by two heavily constructed longitudinal overhead trusses, which extend the entire length of the pontoon on each side of the well. The bow gantry, which is pin-connected to the deck, is of heavy steel construction, extending well forward, and 35 ft. above the deck. This makes it possible to raise the lower tumbler 10 ft. above the water-level, so that repairs can be carried on quickly and easily on the bank ahead of the dredge. Heavy steel cables connect the top of this gantry to the main trusses supporting the upper tumbler, using an equalizing sheave to get equal strain on each side.

The buckets are made in two pieces, the bottom and hood cast in one, and made of manganese steel, and the lips, also of manganese steel. The upper tumbler is made from a single six-sided high-carbon steel casting, with lugs cast in place to give a positive drive to the bucket-chain. The wearing parts are faced with manganese steel plates. The revolving screen, which is 7 ft. inside diameter by 36 ft. over all, has been provided with rib bars and retarding rings of manganese steel, placed inside in such a manner that they prevent the material passing through the screen without being broken and disintegrated under high-pressure water jets which release the tin. Travelling cranes are provided for handling all the heavy parts of the machinery, and a jib crane is placed at the forward end for use in changing buckets and making repairs.

One 12 in. high-pressure centrifugal pump delivers water to the screen and hopper. The tin-saving tables receive their supply from a 14 in. centrifugal pump. The piping system gives complete control of the water to any part of the dredge. The bucket-chain and ladder-hoisting machinery are driven by one 150 h.p. motor taking 2,200 volts. Each of the other units is driven by a separate motor. The lever room is placed forward on the starboard side of the dredge, and from this point all winches and brakes are operated by one man who commands a view of the bucket-line when digging and of the Chinese coolies working on the tin-saving tables.

The plant will treat 130,000 cubic yards of gravel per month at a very low operating cost. The average cost for this kind of work in California is 2½ to 5 cents per cubic yard, and in the Malay States and Siam about the same figure, so it will be readily seen that good profits can be made on ground yielding an average of 1 lb. of tin concentrate per cubic yard.

THE PONG DREDGE. — The East Asiatic Company of Copenhagen has recently put in operation on alluvial tin deposits at Pong on the Kopah River, Siam, a bucket-dredge with a 5½ cubic foot close-connected chain of buckets. Mr. George H. Thurston, of London, is the consulting engineer for the East Asiatic Co. A hydro-electric power plant consisting of a 500 k.w. generator-set and Pelton water-wheel furnishes power for the dredge over a transmission line four miles long. The property is about 60 miles from the mouth of the Kopah River, and the dredge was transported to the site by means of shallow-draft barges and native boats. As part of the dredge had to be transported during the dry season when the river was very low, some difficulty was encountered, but this was minimized by the dredge being sectionalized to meet this situation. The dredge will dig to a depth of 30 ft. below the water-level of the paddock when the ladder is at an angle of 45°, and the bucket-chain has an approximate speed of 55 ft. per minute when working under normal conditions.

The pontoon, of heavy steel construction throughout, is 115 ft. long by 45 ft. wide and 10 ft. deep, and is stiffened by longitudinal plate-girder trusses between decks the entire length of the hull. These are the continuation of the well-hole plate, and additional strength is given by three water-tight transverse trusses between decks forming part of water-ballast tanks, which can be used, if necessary, to regulate the trim of the dredge when operating. The upper tumbler and drive are carried on two longitudinal overhead trusses of heavy construction that extend from bow to stern on each side of the well. The tin-saving sluices are so designed that the concentrate may be removed from any one while the dredge is in operation, by diverting the supply from the distributor to special sluices provided for this purpose. As the material leaves the screen it is carried forward by the distributor to transverse distributing sluices which feed the main tin-saving tables. The tables, by this arrangement, are carried well forward on the pontoon, thus minimizing the liability to change the trim of the pontoon as the material accumulates.

The bucket on this dredge is made in two parts, the combined bottom and hood being of special heat-treated carbon steel casting, with a manganese steel lip. The old-type hexagonal lower tumbler has been discarded for one made from a single steel casting with circular tread and flanges faced with manganese wearing plates. The top tumbler has six sides, having large lugs cast on each face that give a positive drive to the bucket chain. All gears are of specially heat-treated steel castings, with teeth cut from the solid blank, and all shafts are made from hammered steel forgings.

The revolving screen is 6 ft. in diameter and 30 ft. long over all, and will be carried by two specially heat-treated steel friction tyres on three friction rollers. Two of the latter are idlers carrying the upper end of the screen, while the lower one is mounted directly below the screen on a horizontal centre line. The screen is held in line transversely by two idler rollers acting against the sides of the lower tyre, and one bevel roller acting against a face on the lower screen tyre takes the axial thrust due to its inclination. No tailing elevator is used on this dredge, the material rejected from the screen being deposited behind the dredge by means of a chute.

A 14 in. centrifugal pump with a capacity of 3,750 gallons per minute delivers water to the screen and screen-casing through a series of nozzles coupled to headers by ball joints so that the water may be directed to any point necessary to thoroughly wash the material. A 14 in. centrifugal pump of the same capacity is also used for supplying the sluices and for freeing the dump-chute and buckets from sticky clay. A 5 in. high-pressure pump is used and delivers its supply through adjustable nozzles, two of which are so directed that they deliver two heavy jets directly into each bucket, thoroughly cleaning it as it passes after dumping. The entire water-supply is so arranged that the operator has complete control of the flow of the material treated on any part of the dredge.

Both jib and travelling cranes are used in positions that will expedite repairs and renewals to all parts of the machinery. A head-line holds the dredge up to the working face. All clutches and brakes on the ladder-hoist, winch, bucket-drive, and all winch machinery are operated by hand levers mounted in a lever room or platform on the starboard side from the winch room and controlled by one man, and in such a position that the operator commands a full view of the working face and front of the dredge, and also of the tin-saving tables. Power is brought on board the dredge at 6,600 volts and transformed to 440 volts. All motors operate on a 3-phase, 50 cycle, 440 volt circuit. A 110 h.p., 1,000 r.p.m., variable speed motor drives the bucket chain. Similar motors drive the various other units. The East Asiatic Company has erected at the mine a machine shop equipped with the most improved machinery to make necessary repairs. One European winchman each shift of eight hours operates the dredge, and native labour is used for all other purposes.

Fulminate of Mercury.

At the meeting of the Birmingham section of the Society of Chemical Industry held on March 21, Mr. G. S. Heaven read a paper on fulminate of mercury. Fulminate is now manufactured by a method closely resembling that used in its preparation by Howard. Five hundred grammes of purified mercury is dissolved in an excess of concentrated nitric acid to make mercuric nitrate. The cooled solution is poured into a large flask containing 5 litres of 94% alcohol at a temperature of about 250° C. In about twenty minutes the reaction is over, and the crystals begin to separate. The mixture is poured into a small quantity of water and the fulminate that separates is washed by decantation. It is then sifted through a fine net filter which serves to remove large crystals, and is finally washed on a finer mesh filter until free from acid. The fulminate is then stored in calico bags under water, and for transportation in bulk the bags containing 20 lb. each are packed in a barrel which is filled with water. For use, the fulminate is washed with distilled water through a 40 mesh sieve into a calico bag. The water is squeezed out, and the fulminate dried at a temperature not exceeding 65°C and pressed to powder.

THE EVOLUTION OF ORE DEPOSITS
FROM
IGNEOUS MAGMAS

By W. H. GOODCHILD, A.R.S.M., M.Inst.M.M., F.G.S.

(Continued from the March issue, page 141).

In this series of articles the Author discusses the principles governing the segregation of ore deposits from rock magmas, introducing several new factors in addition to those already put forward by geologists. He shows how the specific action of certain gases and mineralizers, notably hydrogen and its compounds, together with changes in volume accompanying the later chemical adjustments, explain many obscure problems in the formation of ore deposits.

Introduction to the Theory of Magmatic Differentiation.

We have so far considered the brecciation and other dynamic effects exhibited by the Sudbury ore deposits merely as results of what may be termed "sulphur blasting." This, however, only partly accounts for the phenomena observed. In order to understand many collateral facts observed in the field it will be necessary to review the differentiation and consolidation of the main silicate magma in some detail. Before this can be done effectively we must briefly discuss the fundamental laws of mobile equilibrium, since it is by means of these that it becomes possible to acquire that "some knowledge" of the diagram of thermal equilibrium which metallographic experience demonstrates to be the only satisfactory basis for the interpretation of the structures. That this metallographic experience applies to the problems of magmatic differentiation is recognized by authorities on physical chemistry, for Dr. C. H. Desch says (First Report to the Beilby Prize Committee on the Solidification of Metals from the Liquid State, Institute of Metals, March 1914): "From a physico-chemical point of view, the solidification of metals is *essentially similar* to that of igneous rocks." There can be no question therefore as to the prime necessity of developing the theory of differentiation in rock magmas by way of the laws of mobile equilibrium.

The principle of Le Chatelier (Law 1) may be stated as follows: "When a factor determining the equilibrium of a system is altered, the system tends to change in such a way as to oppose and partially annul the alteration in the factor. The same idea is conveyed by saying that every system is conservative, or tends to remain unchanged. That is, considering a physical or chemical system in equilibrium, the equilibrium being fixed by the nature of the system and conditions such as temperature and pressure, the principle states that if we alter one of these conditions or parameters, say the temperature, the system will change in such a direction as to tend to annul this change in temperature." (Quoted from "A System of Physical Chemistry" by W. C. McC. Lewis, Vol. 2, p. 141). Commenting on this statement of the principle Professor Lewis says: "No proof in the ordinary sense can be given of it; it is a generalization based on experience. It has been applied in all branches of physics and chemistry, and has shown itself to be a valid and *perfectly general* law of nature. Since it involves no assumptions regarding molecular structure of systems, it is to be regarded as a thermodynamical law. As a matter of fact, it is comprehended in the second law of thermodynamics." (*loc. cit*).

It is to be noted: (*1*) The law is valid and perfectly general in its application; it is therefore applicable to the cooling phenomena presented by igneous rocks. (*2*) It will manifest its operation in many diverse ways because the systems of which magmatic geology treats are of vast dimensions and great heterogeneity. (*3*) It is essentially a thermodynamic law and will therefore manifest its operation both by way of thermal and dynamic effects. (*4*) The nature of the geological record is such that solidified rock magmas should show not only the main effects of the cooling process but also the "annulments," these appearing on the whole as lesser or subsidiary effects and giving a variegated appearance to the main results of the consolidation scheme. (*5*) The "annulments" will in general tend to take the form of reversals of the main cooling effects. (*6*) It is essentially an energy law and the rate of loss of free energy depends on the intensity factor or difference of potential between a system and its surroundings. (*7*) The rate of loss of energy also depends on the capacity factor or the ratios of size and surface of a system to its surroundings.

It would appear from the foregoing that we may write the Le Chatelier law in a somewhat different form and say that the rate of diminution of energy of a heterogeneous system tends toward a minimum.

If we make the system of sufficiently large dimensions, the rate of diminution of energy tends to appear as a negligible quantity and in this shape we may correlate the law with the fundamental principle of the conservation of energy.

The law of Van t'Hoff, which may be called the second law of mobile equilibrium (Law 2), fits naturally into the scheme outlined above, for its prevailing tendency to convert free energy into potential energy at high temperatures and to reproduce it as free energy at a later period when the rate of loss of energy has decreased, is in the nature of an annulment.

Another important law (Law 3) is that known as Ostwald's Law of Successive Reactions which states that a system does not pass directly from the least stable to the stable state, but does so through a series of steps or stages of gradually increasing stability. The case of polydymite formation previously discussed may be cited as a simple example of the operation of this law and is one that is closely germane to our main theme of the derivation of ore deposits from igneous magmas.

One other law (Law 4) of considerable importance in magmatic geology, especially from the point of view of ore deposits, is that known as the Law of Distribution, which states that: When two immiscible liquids are brought in contact with a third substance, soluble in each, this third substance distributes itself between the two solvents until its concentration in the one solvent bears a perfectly definite ratio to its concentration in the other. This law is of particular importance in connection with the differential concentration of gases in the submagmas that form in the main silicate melts, and the theory of mineralizers.

Objections have been raised to the application of the Le Chatelier principle to the phenomena presented by the passage of matter in the molten or liquid state into the crystalline solid state on the cooling curve. The geological evidence is so strong as to be conclusive that the principle does apply to this change of state, for it is abundantly evident from the compositions of the rock-forming minerals that every effort is made to postpone crystallization by taking advantage of the laws relating to the depression of the freezing point. A little consideration will show that the postponement of crystallization is an important way of conserving the energy of a molten heterogeneous system. When a liquid crystallizes there is an evolution of free energy—the heat of crystallization. While the substance is liquid this energy is potential and non-transferable. The act of crystallization by converting non-transferable energy into the free or transferable form thus facilitates its escape from the system. It follows therefore that the system will react in such ways as will tend to oppose the passage from the liquid to the solid state, the change being essentially a reversible one.

When a rock magma cools down it eventually passes for the most part from the liquid to the solid state. We say "for the most part" advisedly for one of the most important geological results of the operation of the Le Chatelier law is that some of the constituents of a rock magma never do reach the solid state. Some of the water, for instance, finally escapes to the surface even if the magma is consolidated at great depths. Our atmosphere and the oceans are thus ever present reminders of the operation of the Le Chatelier law.

Physical chemists have not hitherto put forward any generally applicable theory of the solid state. It is this change from the liquid to the solid state that is one of the most remarkable phenomena that accompany the cooling of rock magmas. There are such marked differences in many of the properties of matter in the liquid and solid states respectively that it will scarcely be out of place to briefly consider the phenomenon of solidification with a view to attempting to picture its inner significance. If instead of looking on the surface of the earth for the moment we cast a glance toward the heavenly bodies we may note that they move as masses or systems in two different ways, namely, movements of translation and movements of rotation. If we rapidly rotate a heterogenous system of any shape or size not merely on one fixed axis but about a point within the system so that we continuously and rapidly change the axis of rotation, or, to put it in another way, give the system extremely rapid precessional motions in all possible directions, it matters not what the real configuration of the system may be, it will appear and behave as an elastic sphere. Let us suppose gas molecules not only to have motions of translation but to be heterogeneous systems rotating on axes the orientations of which continually change at high velocity. While there is plenty of "empty" space between them they will behave as a collection of elastic spheres moving at high speeds and in the main without influence on each other's motions of translation. Reduce the space between the systems but retain the rotary motions and we can in this way develop the properties of the liquid state. If however we reduce the intervening space still further so that the rotating systems develop a "brake" action by mutual friction, there will be a conversion of rotary motion into heat and the development of internal friction or cohesion. Lastly if we imagine that this conversion of energy of rotation takes place in such ways as either to stabilize, fix, or definitely orientate rotation on one axis only or possibly indeed to cause a cessation of rotary motion, the actual configuration of the system will tend to appear and with it a new set of properties arising as expressions of the true shapes, volumes, and internal arrangements of the systems or molecules. Some liquids expand on solidification, and this at first sight might seem to run counter to this conception, but it is obvious that internal expansions are quite as capable of developing internal friction as contractions. In some such way as this it seems possible to picture an outline of the passage from the gaseous to the liquid and from the liquid to either the amorphous or crystalline solid state.

These speculations as to the nature of the solid state are submitted tentatively since they undoubtedly require further testing and discussion. They are given here from a conviction that the solution of many of the vexed problems of metallurgy and geology such as hardness, strengths of metals, etc., require the aid of some working hypothesis as to the essential nature of the solid state.

If we carefully bear in mind the various considerations set forth in the foregoing discussion on mobile equilibrium we have a valuable bunch of keys for unlocking the doors of the mystery palace of magmatic differentiation.

The Principles of Magmatic Differentiation.

Space will not permit of an elaborate treatment of the many details of magmatic differentiation, although the subject is usually regarded, and rightly so, as the most fundamental problem of modern petrology. Nevertheless it is hoped that the following discussion will be sufficient to outline the more salient features and principles in so far as these are necessary to a broad understanding of the formation of ore deposits from igneous magmas, and in addition to suggest useful lines of research.

A brief discussion on more rigidly physico-chemical lines than can be found in current geological literature is indeed vital to our subject, and necessary, as this literature does not contain any adequate solution of many of the more important problems of magmatic geology. The ultimate source of primary rock magmas and the causes of initial variations in their composition does not come within the scope of this part of our inquiry. Similarly, the means whereby they are brought into position, and such collateral problems as magmatic stoping, are deemed to be too remotely connected with the actual formation of ore deposits to make their general discussion a profitable undertaking, though in special cases magmatic absorption of the surrounding country (hybridism), and chemical reactions at igneous contacts, may be more or less directly responsible for the formation of ore deposits. The kind of contact action here referred to must not be confused with the processes that give rise to the more usual kind of contact metamorphic deposits. Magmatic differentiation in the sense here used is concerned with the phenomena of the cooling curve of the rock magmas subsequent to their intrusion or extrusion. Although the more remote causes of igneous action are thus left out of consideration, it will appear later that subsidiary vulcanicity may, and does, arise as an integral part of the cooling phenomena of the larger masses of rock magma. Moreover, this secondary or subsidiary vulcanicity is a most important factor in the concentration of traces of the valued constituents of magmas into ore deposits. The elucidation of the principles of magmatic differentiation as here defined may thus serve as a connecting link between the more superficial aspects of igneous action and those conditions and processes so deep-seated within our earth as to be outside the range of direct observation. The latter are the subject of cosmogonic speculation concerning which we shall say something later.

It will be convenient to divide this discussion into three subsections, as follows: (1) the constitution of rock magmas, (2) mineralizers and pneumatolysis, (3) crystallization differentiation. The sequence is a natural one, since the first leads to the second, and the second to the third. Crystallization differentiation in its turn provides the key to the mechanisms of isostatic readjustment involving crust movements, mountain building and crustal depression, thermodynamic metamorphism, earthquakes, the genesis and modes of action of volcanoes and subsidiary vulcanism, faulting and fracturing, as well as many other features and processes that together go to make up the vast programme whereby ore deposits are evolved from rock magmas.

The Constitution of Rock Magmas.

Magmas differ among themselves, not merely as regards their chemical composition, but also as regards what may properly be regarded as their physical constitution, though it is not possible to draw any sharp line between physical and chemical phenomena. The essential difference between a smelter's slag and a natural magma lies in the presence to a greater or less degree in the latter of the constituents of the familiar, easily volatile, oxide of hydrogen, water, H_2O. At first sight this seems to be a very simple difference, but as a matter of fact it is one that has the most far-reaching consequences and importance. It must be remembered that hydrogen occupies a unique position among the chemical elements, while the state of the hydrogen that appears practically invariably in an oxidized form on consolidation of the melts, depends, during the fluid life of the rock masses, on quite a large number of variable factors.

H_2O under ordinary conditions is so nearly a neutral substance—that is to say it is neither pronouncedly acid nor alkaline in its behaviour—that its acidity can only be detected by refined methods of measurement. Its acidity rises appreciably with increase of temperature. If we examine the properties of the respective hydrogen compounds of nitrogen (atomic weight 14), oxygen (16), fluorine (19), chlorine (35·5), namely, H_3N, H_2O, HF, HCl we find the alkali ammonia at one end of the series, then water almost neutral but very faintly acid, next hydrofluoric acid a weak acid, and at the other end of the series hydrochloric acid a very strong acid. That is to say, an increasingly acid character accompanies the increase of atomic weight of the electronegative radical. Hydrofluoric acid, in the sense of the ionic theory, is only slightly dissociated in concentrated aqueous solution, but it becomes highly dissociated in dilute solution; in other words its acidity is increased or developed by dilution in a suitable solvent. Now it is obviously impossible to increase the acidity of a mass of water by adding water, but by analogy we should expect the acidity of water to be similarly developed or increased by dilution with a suitable solvent. Silica seems to be such a suitable solvent, for the electric conductivity of magmas containing an excess of silica over basic oxides has been experimentally demonstrated by Barus and Iddings to be greater than that of basic magmas at corresponding temperatures. Thus the relationship of an anhydrous melt to a natural magma is, in one important sense, analogous to that of the normal to the acid salt. There is, however, this important difference, namely, the proportion of the acid, or hydrogen ion, is less than in the case of the low temperature acid salts, such as bicarbonate of soda, with which we are familiar in the chemical laboratory. We may pursue the analogy further, and compare the effects of heating on such an acid salt as bicarbonate of soda. Under these conditions the acid salt behaves as a remarkably free-moving liquid, although the gases to which the mass owes its mobility are not *in solution*, and the other constituents are much below their melting temperature. These points have an important bearing on the very low temperatures at which natural magmas consolidate as compared with artificial slags, as well as the rôle of mineralizers. The latter are commonly described as fluxes, and the fluxing action is considered as *identical* with solution, an assumption which is scarcely justified in the light of modern researches on emulsions and similar fluids. It will be shown later that the acid-salt hypothesis of magma constitution correlates a great number of magmatic phenomena that are otherwise wrapped in obscurity. It is therefore a conception of fundamental importance and utility in the study of ore deposits derived from igneous magmas.

Intimately connected with the acid-salt aspect of magma constitution is the nature and degree of the fluidity of rock magmas. It would appear from what has already been said that the viscosity or fluidity of rock magmas is not a mere question of the melting points of the difficultly volatile constituents, or the depression of freezing points, in the sense of the solution theories alone, but that this fluidity is also largely to be attributed to "gas emulsification." Closely connected too with this gas emulsification is the crystallization and differentiation in magmas by means of "foam cells." The foam-cell theory is now engaging the attention of metallographers, and evidence is accumulating as to its soundness and wide application. The position in 1912 was summed up by Sir. G. T. Beilby as follows: "While it may not be possible to establish Quincke's view that in all cases solidification is preceded by segregation and development of a 'foam cell' structure, yet among recorded observations there are some which give colour to the view that at any rate in alloys and impure metals there is segregation *under the influence of surface tension* in the liquid or the partly solidified state" (see the "Solidification of Metal from the Liquid State," by G. T. Beilby, Institute of Metals, 1912). Since that date much additional metallographic evidence in favour of the foam-cell theory has been obtained. (Private communication, Prof. H. C. H. Carpenter).

I have already shown relationships between internal pressure and the constitution and natural synthesis of certain sulphide minerals, while internal pressure is intimately related to surface tension. The essential similarity between solidification of metals and that of igneous rocks has also been pointed out. There is little room for doubt, therefore, as to the probable importance of "foam cells" as a factor in rock-magma crystallization and differentiation. Sir G. T. Beilby goes on to say that "the more general inquiry as to the changes which precede solidification of metals appears to be a promising territory which is awaiting exploration." These conclusions clearly apply with equal force to the solidification of the constituents of ore deposits and the magmas from which they are derived. Again it seems desirable for the general benefit of the metallurgical industry that there should be closer co-operation between metallographers and geologists.

Another aspect of magma constitution that requires brief consideration is the state of the oxides. On the whole it seems probable that the best way to view this matter is that all states of dissociation and association are present in the melts, but that fall in temperature is in a generalized sense accompanied by increasing association into systems of greater complexity.

To deny the presence of free oxides in the magmas is probably as mistaken a view as to suppose that the so-called silicate melts are composed entirely of silicates as such. Furthermore alumina does not function merely as a base. The spinellid association clearly points to alumina acting as an acid under certain conditions, and the probable presence of acid-functioning alumina in association with bases that are incapable of forming separately crystallized spinellid minerals is one that should not be overlooked. The frequently observed sympathetic variation of soda with alumina may be instanced as pointing to the presence of alkaline aluminates as such rather than to the operation of "felspar molecules" as the units of variation, which is the interpretation of this phenomenon usually given by petrologists. The alkaline aluminates may thus be important factors in postponing solidification, especially in acid magmas.

There is also in all probability an essential difference between acid and basic magmas arising from the variations in the concentrations of the iron oxides. In basic ferruginous magmas the hydrogen is probably present for the most part as H_2 rather than H^+, hydrogen ion, and the corresponding amount of oxygen required to form water on crystallization of the silicates being combined in the shape of Fe_2O_3. In acid magmas, such as granite, there is not usually a sufficient quantity of the iron oxides to satisfy this equation, but dissociation of the water in such magmas is probably for the most part of the ionic kind, hence their higher electric conductivity.

It may be as well to point out here that although the iron oxide—water mechanism is easily reversible almost isothermally, it is singularly sensitive to pressure variations increase of pressure tending to drive the reaction in the sense of increased liberation of hydrogen, as will be obvious from density considerations of the substances involved in the reaction. The importance of this difference between acid and basic magmas will be brought out more fully in discussing the formation of magmatic iron ore deposits.

Summarily it may be said that our knowledge of the constitutions of rock magmas is still in the early stages of its development, while experimental investigations of anhydrous melts do not appear to be capable of shedding anything more than a very limited amount of light on the problems of differentiation in natural magmas. In fact, such investigations are apt to lead to quite erroneous conclusions unless the many essential differences that arise primarily from hydrogenation are fully recognized and allowed for.

Mineralizers and Pneumatolysis.

The French school of geologists has long emphasized the importance of "mineralizers" in the chemistry of rock magmas, but hitherto there has been an air of mystery surrounding the precise nature and modes of action of these elusive substances. The great mineralizer is undoubtedly hydrogen, and it acts either in the free state or in conjunction with electro-negative radicals. Hydrogen is a kind of molecular sliming device. It enters into combination with such substances as oxygen, sulphur, arsenic, and many other elements and radicals, splits up the otherwise polymerized molecules, and presents them to the metals and bases in a suitable form for assimilation. This splitting power of hydrogen will be obvious from a comparison of the molecular complexities of the hydrogen compounds with those of the elements under like conditions. For instance, elemental arsenic has four atoms in the molecule at moderately high temperatures, but under corresponding conditions arseniuretted hydrogen, AsH_3, has only one atom in the molecule, as deduced from vapour density determinations.

The next point is perhaps more hypothetical, but there are grounds for believing that hydrogen plays an associating rôle as well as this splitting action. As has been shown, the various metals condense the electro-negative radicals in different degrees. It seems not at all improbable that these hydrogen compounds are easily polymerized or condensed at *surfaces* up to the degree of condensation or polymerization required for easy combination with the metal. When this has been attained, the hydrogen is again liberated. This may be described as a catalytic function of hydrogen. There are a number of significant facts bearing on this view, among which may be mentioned the many well-known catalytic industrial applications of hydrogen, and the fact that many reactions between a variety of substances are inhibited in the absence of hydrogen either free or combined. Thus hydrogen appears to exert a kind of concertina action, expanding the electro-negative elements and radicals by its dissociating action and compressing or condensing them at suitable surfaces.

Hydrogen, however, is the acid-forming element. Thus our mineralizers are essentially nothing more nor less than the acids with which we are familiar in the laboratory, and the subject of mineralizers thus becomes divested of much of that mystery with which it is surrounded in current geological treatises. In this way hydrogen sulphide may be described as the mineralizer of the sulphides and, as we have shown, the facts of occurrence at Sudbury and elsewhere fully confirm this conclusion. Similarly arseniuretted hydrogen may be regarded as the mineralizer of the arsenides, telluretted hydrogen that of the tellurides, and so forth.

Similarly we may deal with the oxy-acids, but these show an increase in complexity. The ratio of hydrogen to sulphur is fixed in the case of acids of the H_2S type so long as dissociation has not taken place; but in the case of oxy-acids such as titanic acid, for example, the ratio of H_2O to TiO_2 may vary between wide limits as well as the proportion "free" TiO_2 to combine in the "acid salt." Similarly for silicic acid, $SiO_2 nH_2O$, chromic acid $Cr_2O_3 nH_2O$, the respective mineralizers of certain silicates and the chromium minerals of the spinel type, and the oxy-acids generally.

Setting aside silicic acid for the moment, and confining our attention to the acids that are present only in relatively small amounts in rock magmas, it is important to inquire more particularly how these various mineralizers or acids act. We can now generalize, and lay down certain broad principles concerning the action of mineralizers as a whole. If we wish to precipitate, say, copper sulphides from aqueous solution we generate H_2S externally and pass the gas into the solution, and the result is to produce flocculent aggregates of copper sulphide which remain to some extent suspended in the liquid. Precisely what causes the agglomeration of the molecules into such complex masses as the individual "flocks," as apart from the mere rendering insoluble of the molecules, is a matter concerning which we know next to nothing.

In a rock magma we may fairly assume that at high temperatures the H_2 and the S are at first uncombined, but association into H_2S takes place with fall in temperature and is accompanied by the evolution of heat proper to the formation of H_2S. Thus instead of generating our precipitating acid externally it is generated internally as a part of the normal process of cooling. As cooling proceeds further, the acid precipitates the salts, the sulphides in the special example chosen, and this precipitation is accompanied by a further and more intense evolution of heat, since the heats of formation of the metallic compounds are greater than those of corresponding hydrogen compounds. Thus the course of events proceeds in accordance with Law 2 (see page 187). The precipitates, by analogy, probably tend to agglomerate to some extent, though how this agglomeration is produced we do not know. The minute and widely disseminated particles of precipitate which will be in the liquid, in contradistinction to the flocculent, state, constitute sub-magmas which become solvents for their particular acid on account of the similarity of molecular type. By solution and emulsification of the precipitating acid with the precipitate, a two-phase, gas-liquid suspension is developed within the main magmatic bath. But just as in the main magma the acid is to some extent ionically dissociated, so we may infer that ionic dissociation occurs in the sub-magma. Furthermore the degrees of dissociation are specific properties of the various acids and salts. Thus the concentration of the hydrogen ion for instance in the sub-magma will tend to be seriously different from that in the main magma. But this specific concentration is probably an unstable or rather a metastable arrangement as between the two magmas, and some differential migration of the ions will be required to establish equilibrium in the sense of Law 4. Thus the sub-magmas will tend to acquire electric charges, which may be positive or negative according to circumstances, while the gas concentration in the two magmas will be different. The sub-magmas so developed consist of two-phase, gas-liquid, electrically-charged particles suspended in a bath, which in its turn occupies a magnetic field of varying intensity. In this way a number of systems are generated which can be concentrated into much larger masses or magmas by variations in temperature, pressure, and electromagnetic agencies; that is to say, they will tend to migrate within the main bath in accordance with the magnitude and intensity of the various factors brought to bear on them. Obviously the solidifying temperature range of the sub-magmas will be depressed in a similar fashion to that of the main magma in accordance with Law 1. The sub-magmas are also essentially metastable phases, and pass into the solid state by way of successive reactions in accordance with Law 3.

In general we may express the relationship between the sub-magma formed by means of the mineralizer in terms of the Greek idea of the relationship of the microcosm to the macrocosm.

This generalized view is of interest, because it affords a basis for correlating many of the larger features of the differentiation processes manifested by the main magma with those developed on a much smaller scale in connection with the sub-magmas. For instance, the so-called "law of decreasing basicity" applies in a general way to the consolidation of oxy-acid sub-magmas, as can be shown by geological evidence.

The "degree of acidity" of a sub-magma is also necessarily a function of the degree of acidity of the main magma in which the sub-magma is generated. Thus when the main magma is an acid one, the sub-magma in a generalized sense tends to be similarly acid, for the simple reason that the concentration of bases is insufficient to permit of the complete "fixing" of the acids into neutral salts. In the case of sulphides, arsenides, and salts of this type, the gas concentration therefore tends to be high in acid magmas but low in basic. Thus in acid magmas the tendency is for the sub-magmas to be concentrated in the upward sense, that is to say, flotation, while in basic magmas gravity concentration will tend to take place. Since basic magmas are subject to gravity differentiation by the sinking of early formed crystals, the sub-magmas will likewise tend to be concentrated by the sinking crystal swarm in much the same way as a turbid aqueous solution may be "cleared" by means of a heavy clean settling precipitate. Here again the difference between low temperature artificial flotation and magmatic flotation is that in the former the gases are developed externally to the particles to be floated, while in the latter they are developed internally.

The degree of hydrogenation of the sub-magmas must also be a function of the degree of hydrogenation of the main melt, a highly hydrogenated melt tending to give highly hydrogenated sub-magmas and consequently a more intense hydrothermal aspect to the ore deposits developed on consolidation of the sub-magmas.

The case of the oxy-acids is perhaps a little more involved, for the relative acidity or affinity for bases of the acid anhydride, coupled with the nature and concentration of the bases in the main magma, must play important parts in determining the amount of "unfixed" anhydride in the sub-magma. Thus in a sub-magma consisting for the most part of ferrous titanate, for instance, the amount of "unfixed" TiO_2 will depend not only on the silica percentage in the main magma but also on the iron concentration in the magma and in a more indirect manner on the concentrations of the other constituents, particularly the bases. The characters of the ilmenite deposit which may result from the concentration of the erstwhile suspended sub-magmas will be to some extent an expression of the peculiarities of the main magma. Such deposits may show intense hydrothermal alteration in their neighbourhood with but very subordinate development of secondary ilmenite, rutile, sphene, etc.; or hydrothermal alteration may be insignificant, but be accompanied by considerable development of secondary ilmenite and other titanium minerals, replacing other minerals metasomatically.

Since generation of the free acid takes place internally and on the cooling curve, there is probably a maximum point in the rate of generation which will also cause variations in the composition of the sub-magmas and will effect the gas concentration in the sub-magmas formed at different stages in the cooling process.

The miscibility of sub-magmas is also a matter of importance. Artificial mattes and speisses have very limited miscibility, but it is probable that the hydrogenated natural mattes and speisses are freely miscible in all proportions, the mixtures being differentiated into sulphide and arsenical minerals during the consolidation process. Arsenopyrite itself is essentially an undifferentiated mixture of pyrite and löllingite, as can be shown from density considerations.

What appear to be very dissimilar acids may occur together in the same sub-magma. The fluo and chloro-phosphates may be cited as instances of this. Apatite, the commonest solid representative of this class of sub-magma, crystallizes so early in the general consolidation scheme of rock magmas that it is questionable whether crystallization does not in most cases take place without the formation of fluophosphate sub-magmas. The phenomena presented by apatite veins and such minerals as amblygonite, which yield free acid on heating, indicate that the halogen phosphate association represents to some extent a transition group between sub-magmas which may have a prolonged existence as such in the main magma and those whose period of existence may be curtailed practically to vanishing point by variations in the external circumstances. This point will become more evident when the nature of pneumatolysis has been discussed. The association of the halogens with phosphoric acid, which at first sight seems a little peculiar, will also be shown later to be intimately connected with volume relationships. One of the most remarkable features of mineralizers that has appeared so mysterious in the past is the absence of the supposed mineralizer from the finished mineral. It will be obvious from the foregoing discussion that it is hydrogen that is at the root of this mystery, and this substance finally appears in the innocent form of water.

In general, if we examine the broad facies of the sulphide, arsenide, telluride, chromite, ilmenite, magnetite, cassiterite, wolframite, phosphate, etc., deposits, we find that in their forms, geological positions, and collateral silicate alteration there are the closest resemblances. The variations are of the same order, and to such an extent is this the case that we may reasonably infer that the fundamental principles governing their precipitation and concentration in rock magmas and the subsequent consolidation phenomena are essentially the same, the differences relating to detail rather than principle. The acid-salt hypothesis thus gives promise of enormously simplifying the correlation of a large number of diverse and seemingly disconnected facts.

There is another aspect of mineralizers to which brief allusion must be made, namely, the possible catalytic part that may be played by such substances as manganese oxides, tungstic acid, etc. It is possible that the former may play an important part in the fundamental iron oxide—water reaction, and in this way influence the concentration of free hydrogen in rock magmas. There is also experimental evidence to suggest that substances such as tungstic acid may play a part in the formation of minerals in which the acid itself does not appear.

While the possibilities of catalytic reactions of this kind should not be overlooked, on the whole it seems probable that hydrogen itself is the principal active catalyst in the magmatic laboratory. Although such rarities as tungstic acid, lithia, etc., may be employed in the artificial synthesis of certain minerals, it is doubtful whether they play a similar part in the natural synthesis of those minerals in connection with which they have been used.

There is another important way in which the presence of mineralizers may seriously influence the mode of segregation of ore deposits from rock magmas. The presence of relatively large quantities of fluorine, boron, etc., in a magma may inhibit or postpone to a greater or less degree the precipitation of sub-magmas. Thus instead of an early precipitation of sulphides, and their concentration by flotation to the upper margin, previous to solidification of the upper regions of the melt, subsidiary acidification of magmas by boric and hydrofluoric acids may prevent precipitation. This action has its counterpart in the everyday laboratory chemistry of aqueous solutions. Under such circumstances as these it is not until the rending of the crust is effected and subsequent to a good deal of silicate crystallization that ore deposits are formed from the internally concentrated liquors, and these take the form of veins, etc., of a more or less intense pneumatolytic type, in contradistinction to the contact metamorphic or marginally squirted deposits. The Cornish deposits, of course, may be cited as classical examples of the results of postponed precipitation of sub-magmas arising from the presence of abnormal proportions of acids other than silicic in the main melt. In contradistinction to this postponement by acids, similar effects may also be produced by suitable concentrations of bases or alkalies in the magma. The monzonitic type of magma, which is such a frequent generator of ore deposits in North America, seems to have this property in marked but varying degrees.

Intimately connected with the subject of mineralizers is that of pneumatolysis. Just as the nature and action of mineralizers becomes simplified and intelligible in the light of the acid-salt hypothesis, so pneumatolysis may be reduced to an expression of simple principles based on well-known laboratory reactions and processes. When fractional crystallization of anhydrous minerals takes place in a rock magma the residual liquor gradually becomes enriched in water or the constituents of water. In the case of magmas containing such substances as fluorine and boracic acid it follows that as silicate crystallization proceeds the residual fluorine and boracic acid compounds are in effect being more and more transferred from a state of mutual fusion with silicates into one of aqueous solution, that is to say, solution in a strongly dissociating solvent. Thus their acid salts progressively become more and more ionized or acid as crystallization of silicates proceeds. Compare with what was said earlier in regard to hydrofluoric acid and the general chemistry of normal and acid fluorides and borates. This progressive increase in acidity may be described as high-temperature hydrolysis, and differs in detail though not in principle from ordinary low temperature electrolytic dissociation and hydrolysis of salts of weak acids. On formation of fissures in the silicate crust these residual liquors, consisting of highly dissociated solutions of the acid salts, are thus, as a result of cooling and the concomitant crystallization of silicates, able to corrode and build up new minerals at lower temperatures at the expense of earlier minerals formed by direct crystallization from the same main magma at higher temperatures. The increase of corrosive power of fluorine, chlorine, boracic acid, and sundry other acid-forming radicals with fall in temperatures, which at first sight seems a little paradoxical, is thus easily explained by the aid of those working hypotheses which are the everyday tools of the modern trained chemist and metallurgist. Although the acid-salt hypothesis is capable of wide application in connection with the phenomena of metasomatism, it may be as well to point out that metasomatic processes are in many instances due to modes of molecular interchange that are not to be attributed to the intervention of acid salts.

There is also another kind of pneumatolysis which is more nearly akin in its mode of initiation to the escape of occluded gases, such as often takes place on cooling ingots or other masses of metal. The formation of blow-holes in steel ingots and the "spitting" of silver assay beads may be cited as familiar metallurgical examples. These simple phenomena may be regarded as the prototype of the kind of pneumatolysis that results from the final "fixation" of acid salts or sub-magmas. In the sense of the ionic theory, the pneumatolytic effects produced in this way may be classified as positive or negative according as they are produced by the positive or hydrogen ion or by the negative ions, such as sulphur, arsenic, etc. The two kinds are invariably developed in more or less close association, as we have seen in the case of the Sudbury deposits, though they vary in intensity. The fixation of oxy-acid sub-magmas is necessarily accompanied by varying degrees of hydrothermal alteration, but iron reduction may be absent, or at any rate only a subordinate feature. In the case of the non oxy-acids, the fixation of the hydrogen necessarily involves its oxidation, which takes place at the expense of iron oxides. Thus the local occurrence of iron-bearing formations may not infrequently determine the position of ore-shoots.

The "rotting" of one or both of the lode walls as an integral part of the ore deposition may also be frequently due to positive pneumatolysis; but in contradistinction to this positive pneumatolysis is the partial replacement that is effected by the "fixation" of the free acid anhydride or electro-negative ion. Obviously porosity may be an important factor in determining the locus of ore-shoots developed in this way.

(*To be continued*).

Quicksilver in the United States.

The output of quicksilver in the United States during 1917 is reported by Mr. H. D. McCaskey, of the Geological Survey, at 36,351 flasks of 75 lb. each, valued at about $3,857,000. This figure was the highest since 1883. The increase in 1917 over the production of 1916 was 6,419 flasks. The producing States were California, Texas, Nevada, Oregon, and Arizona. The output of California in 1917 was 24,251 flasks, against 21,045 flasks in 1916. Texas produced 10,759 flasks against 6,306 flasks in 1916. The Nevada output decreased from 2,198 flasks in 1916 to 916 flasks in 1917. In Arizona and Oregon, combined, the production was 422 flasks in 1917 against 383 flasks from these States and Washington, combined, in 1916. The exports of quicksilver for the first 10 months of 1917 were 10,222 flasks, against 8,880 flasks for the entire year 1916, and the imports were 4,491 flasks for the first nine months of 1917, against 5,659 flasks for all of 1916. The high prices received in 1916 and 1917 were due to greatly increased war demands.

THE INSTITUTION OF MINING AND METALLURGY.

The 27th Annual Report of the Council.

We give herewith extracts from the report of the Council of the Institution of Mining and Metallurgy for the year 1917, read at the annual meeting held on the 11th inst.

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The Council in their report for 1916 referred to their action in regard to the establishment in London of a "Department of Minerals and Metals," to collect and co-ordinate information relating to the mineral resources of the Empire, to stimulate its dissemination, and to advise upon measures for protecting and extending the mining and metal industries in the manner best calculated to promote the national safety and welfare. They also referred to the proposal submitted by the Institution of Mining and Metallurgy to the Iron and Steel Institute, the Institute of Metals, and the Institution of Mining Engineers, and afterwards sent to the Imperial Government and to the Governments of the Dominions as a joint recommendation by the four Institutions. The proposal was approved in principle by these authorities, and has since been the subject of consideration in detail by various official bodies.

The following resolution was unanimously adopted by the Imperial War Conference which met in London during the spring of 1917:

"That it is desirable to establish in London an Imperial Mineral Resources Bureau, upon which should be represented Great Britain, the Dominions, India, and other parts of the Empire, the Bureau should be charged with the duties of collection of information from the appropriate departments of the Governments concerned and other sources regarding the mineral resources and the metal requirements of the Empire, and of advising from time to time what action, if any, may appear desirable to enable such resources to be developed and made available to meet the metal requirements of the Empire; that the Conference recommends that His Majesty's Government should, while having due regard to existing institutions, take immediate action for the purpose of establishing such a Bureau, and should as soon as possible submit a scheme for the consideration of the other Governments summoned to the Conference."

Since the adoption of this resolution, the proposal has been further dealt with by committees appointed by the Imperial Government, by the Ministry of Reconstruction, and other Government Departments. The urgent necessity has been recognized of establishing an efficient central organization to co-ordinate all branches of work connected with the mineral resources and industries and of bringing to an end the present wasteful expenditure of effort and money resulting from so many different departments dealing with the subject, and the final decision of the Government is now awaited.

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In their previous report, reference was made to the fact that a joint committee was appointed at a public meeting of representatives of mining companies in August, 1916, to act with the Council of the Institution in an endeavour to obtain an adjustment of the incidence of taxation on the mining industry with immediate reference to the excess profits duty. The joint committee in charge of the matter is constituted as follows: Mr. John H. Cordner-James* (*Chairman*), Lord Harris, Sir Lionel Phillips, Bart., Sir Alfred Mond, Bart., P.C., M.P., Sir Trevredyn R. Wynne, Messrs. F. W. Baker, Edmund Davis, F. A. Govett, F. H. Hamilton, Edward Hooper,* E. W. Janson,* Edgar Taylor,* Henry C. Taylor, Leslie Urquhart, Stephen Vivian,* and Oliver Wethered. During 1917 the committee had numerous conferences with the Inland Revenue authorities and the Board of Referees (appointed under the Finance No. 2 Act, 1915), with the object of establishing general principles affecting the main factors which form the basis of claims for a revised statutory percentage. As a result of these negotiations, the revenue authorities accepted the committee's claim that mines are wasting assets and that amortization of capital during life should be allowed, and the revenue authorities, in agreement with the Board of Referees, requested the Institution to take two selected groups—one gold and one copper—and to present them as representative cases. The two groups eventually agreed upon were gold mining in West Africa and copper mining in Australia, and the West African case was taken first. The preparation of this case and the information required by the revenue authorities necessitated an extensive investigation which occupied several months and entailed a pre-

* Appointed by the Institution.

liminary examination of the records for ten years past of over 250 companies, the results of which had to be classified and submitted to accountants for verification and for detailed calculations for the preparation of tables, etc. The case was finally heard on February 21 and 22, with the result that the Referees made an order increasing the statutory percentage of 6% to 22½% for West African gold mining companies, with additions in respect of circumstances provided for in the Act. While the Council consider that this representative case will be helpful in its effect upon future appeals, they greatly regret that they have been unable to obtain rulings upon principles, which was the chief object of the action of the Institution and the joint committee. Nine alternative methods of computation were submitted by the Institution, but so far as can be seen, the order of the Referees is not based upon any one of them, nor upon the alternative submitted by the Board of Inland Revenue. The joint committee have come to the conclusion in these circumstances that no useful purpose would be served by their submitting the second representative case, and in this view Sir Frank Crisp and Messrs. Spyer & Sons, their legal advisers, entirely concur.

A serious drawback in the whole of the negotiations with the authorities was that the Institution had direct authority only from a part of the companies engaged in the metalliferous mining industry, and that decisions had already been given in sectional appeals which, though not satisfactory, had been apparently accepted by the parties concerned. Serious consideration is therefore being given to the question of organizing the industry more completely so that when the time comes to take active steps in regard to the reform of the Income Tax Acts and other questions, the Institution and the joint committee may speak with the authority of practically the whole metalliferous mining industry.

It may be of interest to add that the committee arrived at an agreement with the revenue authorities upon the main factors upon which applications in metalliferous mining cases should be computed, and this should be of service in connection with the wider question of Income Tax reform. These factors are: (1) wasting assets (amortization during life), (2) deferment (being allowance of interest during the period of development), (3) life, (4) risk of capital. The committee consider that agreement on these main questions will facilitate the settlement of other cases and reduce the labour and cost of preparing appeals to a minimum.

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During the year, 63 members were admitted into the Institution, and there were 38 transfers to associateship or membership, as compared with 72 and 48 respectively in the previous year. The total membership at December 31, 1917, was 2,365, as compared with 2,409 at December 31, 1916, a decrease of 44. Fourteen members, nineteen associates, and fourteen students were removed from the roll; the election of two associates was cancelled; and the resignations of five members, four associates, and three students were received and accepted. The Council record with a deep sense of loss to the profession the fact that during 1917, twenty-six members (one member, sixteen associates, and nine students) were reported as having lost their lives on active service; and they also record with regret the decease of thirteen members, six associates, and one student.

DR. *Receipts and Expenditure for Year ended December 31, 1917.* CR.

EXPENDITURE	£	s.	d.
To Cost of *Transactions* (*for sessional year ended September 30, 1917*)	910	12	2
" Printing and Stationery (*for sessional year ended September 30, 1917*)	123	15	9
" Cost of *Bulletin* (*for sessional year ended September 30, 1917*)	198	8	0
" Meeting Expenses	60	18	9
" Rates, Taxes and Insurance	199	19	2
" Heating and Lighting	44	10	3
" House Expenses	32	6	10
" Telephone	32	8	4
" Audit Fee	31	10	0
" Salaries and Wages (*including allowances to members of the Staff serving with H.M. Forces*)	2,065	5	6
" Postage and Receipt Stamps	180	0	0
" Sundry Accounts	352	6	2
" Interest on Post-Graduate Grants Trust Fund	12	9	0
" Depreciation—Furniture and Library	171	19	4
" Accumulated Fund—Excess of Receipts over Expenditure for the year ended December 31, 1917	378	5	4
	£4,794	14	7

RECEIPTS.				£	s.	d.	£	s.	d.
By Entrance Fees and Subscriptions—									
Entrance Fees				168	0	0			
Subscriptions	£3,989	18	4						
" (Life Compositions)*	47	5	0						
				4,037	3	4			
							4,205	3	4
" Sales of *Transactions*							92	1	6
" Interest and Dividends (including repayment of Income Tax for the years 1913–4, 1914–5, 1915–6 and 1916–7, less charges)							497	9	9
							£4,794	14	7

* Transferred to Life Compositions Capital Account

NEWS LETTERS.

WEST AUSTRALIA.

February 11.

LABOUR CONDITIONS.—The award granted by the Federal Arbitration Court to the miners on the eastern goldfields of West Australia comes into force on March 1. The main concession granted to the employees is the reduction from 47 to 44 hours for six days work. That means that a full week's wages must be paid for a theoretical reduction of 6% in the ore output, but practically it will mean a reduction of not less than 10%. It will take at least one hour to get to the face and back to the shaft, leaving three hours work for Saturday. Overtime for Sunday work is to be allowed, so that a rise of fully 5% on the working costs per ton may be expected. The Oroya Links had to cease mining operations last year, owing to increased costs. The Great Boulder Perseverance is in liquidation, and is crushing ore from the shrinkage stopes together with a little sweetening of new ore when available. The Associated Gold Mines, South Kalgurli, and Lake View & Star are crushing on reduced tonnages or of higher grade than the reserves warrant, and yet are just about paying their way. The Kalgurli can see the end of its ore reserves. With the additional impost for wages, these mines must before long have to seriously curtail their operations or shut down until normal conditions return. The Great Boulder, Golden Horse-Shoe, and Ivanhoe will be the only large producers which have any chance of maintaining their output. The President of the Court said that if the award were found to prejudicially affect the industry, the employers and employees could meet and agree to a revision. With the present blindness of the labour union leaders in Australia, there does not seem to be any prospect of their allowing any alteration. It will only be when the damage is done, and the mines shut down, that the workers will realize that they have been duped into industrial suicide.

THE GOLDEN MILE.—Against this depressing feature, a development which has just been reported is the discovery of possibly a new lode at the 707 ft. level in the Ivanhoe. Mr. J. McDermott, who recently succeeded the late R. B. Nicolson as general manager, is a sound underground man, and a great believer in lateral prospecting. From his experience gained some years ago when underground manager of this mine, he decided to test the country to the west of the Horse-Shoe lode, and although previous prospecting had not been successful he put in a bore-hole from the drift at that level. From 96 to 105 ft. from the drift the assay-value of the core was 34s. per ton; then came 17 ft. of low-grade material; then from 122 to 130 ft. the assay-value was 31s. per ton. It will take very little time to cross-cut to the lode, and if the value of the ore-body is confirmed by driving and sinking it will give a new life to the mine. Another development of importance has been the discovery of a new body of ore by tributers on the Associated Northern Blocks. This party has been at work on a north and south shoot of ore for some years, but recently they intersected a cross lode running toward the Kalgurli. It is stated that £100,000 worth of ore has been opened up. Last month the royalty to the company from this tribute was £790, 786 tons of ore having yielded £3,990.

These two developments show the danger of leaving any ground on the Golden Mile unprospected. More attention must be paid to the economic geology of the district. The weak point in Australian mining is that sufficient encouragement has not been given to mining surveyors to study and follow up geological indications. The underground manager is always anxious to get tonnage, and frequently indications which might lead to shoots of ore are missed and often covered up. The management of the Golden Horse-Shoe mine is a notable exception to this rule. For a number of years a geologist was employed on the mine, and since that date the mining surveyor, who is a qualified geologist, is given full scope to map out and follow geological features. It is fitting that Mr. J. W. Sutherland, who has been general manager of this mine for nearly a decade, should be elected president of the Australasian Institute of Mining Engineers for the current year. In addition to his work as the originator of filter-pressing for the extraction of gold from slime, he has been among the pioneers in metallurgical treatment. He is on the Advisory Council of Science to the Federal Government, and is a graduate of the Ballarat School of Mines.

WESTONIA. — This district is at present the one bright spot in West Australian gold mining. There are eleven companies operating here, of which nine are producing gold, and five, the Edna May, Central, Deep Levels, Consolidated, and Greenfinch, have their own treatment plants. The Edna May has treated 143,137 tons of ore, from which £518,314 has been obtained. The reserves are 50,393 tons averaging 64s. 4d. per ton. Although the end of the mine is not in sight, the lode underlies into the Deep Levels at the 480 ft. level. At the 566 ft. level in the latter mine, the ore-body has so far been opened up for 180 ft. in length of an average width of 15 ft., and the ore is valued at 128s. per ton. There is a winze down 65 ft. below this level on similar grade ore. It will be remembered that whereas the Edna May shaft is making over a million gallons of water per day, the manager of the Deep Levels sank his shaft without encountering much difficulty with water, by boring holes ahead of the shaft-sinking, filling the open fissures with liquid cement under 500 lb. pressure, and so keeping the water back. The other producing mines are of lower grade, but are doing good work. Mr. Blatchford, the Assistant Government Geologist, in his report on this district just published says: "The lodes are of pegmatitic origin, and as they have no extensions beyond the gneissic belt, they must necessarily have come from a deep-seated magma. Their persistence at depth should therefore be assured, though, of course, the size of the veins or their mineral contents is still a matter of conjecture. There seems to be no reason to doubt that the nature of the lode is granitic, and that it represents the acid residuum of a quartz-felspar pegmatite. The occurrence of such lodes is frequent, but the high gold contents such as the Edna May lode possesses is unique in West Australian Mining."

SOUTHERN CROSS. — Owing to the demand for arsenic, and consequently the much enhanced value, several mines, which contained too great a percentage of this mineral to allow them to be made payable as gold mines, are to be worked again. The arsenic will be saved and, supplementing the gold output, will bring them into the producing stage very shortly. The most noticeable of these is the Transvaal mine at Southern Cross, which was sold by Bewick, Moreing & Co. to an Australian firm of metallurgists, who are erecting a plant to treat the ore from this mine, and also the concentrate from the other properties which they have acquired.

COMET VALE.—Some 60 miles north of Kalgoorlie there are several locally-owned mines at this centre, which are regular producers, and give promise of last-ing for some years, provided costs do not soar much higher on account of the rise in prices for stores, and the scarcity and poorness of the labour available. The Sand Queen and Gladsome are the main producers.

MEEKATHARRA.—After many years prospecting, the Gwalia mine has come into its own, and has just crushed 590 tons for a return of £15,028. The mine is on the Feman and Ingleston Consols line, but is about a mile to the south. It is privately owned, and has already produced over £24,000 of gold. The Feman mine has 37,000 tons of ore in sight, and has already paid £384,165 in dividends to its handful of shareholders.

BROAD ARROW.—A find has been made at the old Dark House mine, and from 12 tons of ore over £3,000 worth of gold was obtained. In another abandoned mine in the same district, prospectors have crushed 70 tons for a return of £3,300.

WARRIEDAR.—Considerable interest is being taken in the discovery of molybdenite near Warriedar, South Yalgoo. Some fine specimens have been on view in Perth. A trial lot was sent to New South Wales for treatment and yielded a 95% concentrate by oil flotation.

NORTHAMPTON.—This lead district, which is situated 40 miles north of Geraldton, is turning out a constantly increasing amount of high grade (80%) lead ore and concentrate, which is railed to Fremantle for treatment. The Minister for Mines and the State Mining Engineer have recently made a trip around the field, and speak well of its possibilities. The former hopes to arrange a scheme to assist the men working on small shows, so that they can keep going until the smelter returns are received by them.

TORONTO.

March 11.

MINERAL PRODUCTION DURING 1917.—The preliminary report of the mineral production of Canada during 1917, issued by the Canadian Department of Mines, shows a total value of $192,982,837, as compared with $177,201,000 in 1916, an increase of 8·9%. This is mainly due to the increased prices of metals, as in many cases there has been some decrease in the quantities produced. The metallic production was valued at $106,630,752, showing an increase of only $311,387 over the output of 1916. The production of gold was 747,366 fine oz. valued at $15,449,426, as compared with 930,492 oz. of the value of $19,234,976 in 1916, 58% of the total being furnished by Ontario. The decrease is attributed to the increased cost of labour and materials. Silver shows a fall in quantity from 25,459,741 oz. to 22,150,680 oz., but an increase in value from $16,717,121 to $18,034,419. Copper was produced to the amount of 108,890,358 lb. valued at $29,588,254, as against 117,150,028 lb. of the value of $31,867,150 in 1916. The total production of nickel, nearly all from the ores of the Sudbury district, was 84,470,970 lb. worth $33,778,388, compared with 82,958,564 lb. of the value of $29,035,497. The lead mines produced 32,072,269 lb. of the value of $3,571,889, the output of 1916 being 41,497,715 lb. valued at $3,532,692. Zinc shows a notable increase in quantity since the establishment of the zinc refinery at Trail, B.C., by the Consolidated Mining & Smelting Co. The output (including the zinc contained in ores exported) was 31,227,351 lb. of the value of $2,779,547, as compared with 23,364,760 lb. valued at $2,991,623 in 1916. Shipments of iron ore from Canadian mines were 215,242 short tons valued at $758,261, as compared with 275,176, tons worth $715,107. The Wabana mines, Newfoundland, operated by two Canadian companies, shipped 883,346 tons, as against 1,012,060 tons the previous year. The production of pig iron in blast furnaces was supplemented by a small output from electric furnaces, the total being approximately estimated at 1,171,789 tons. The output for 1916 was 1,169,257 tons. The output of steel ingots and direct steel castings, full returns of which had not been received, was estimated at 1,736,514 tons, showing an increase of 308,265 tons over the production of 1916. The production of electric steel was probably not less than 50,000 tons, as compared with 19,639 tons.

Coal shows a decrease in amount but an increase in value, the figures being 14,015,588 tons, value $47,643,646 for 1917 and 14,483,395 tons, value $38,817,481 for 1916. Coke was produced to the amount of 1,231,865 tons, as compared with 1,448,782 tons. The production of asbestos shows a marked advance owing to the war demand, the output comprising 150,308 tons as against 118,247 tons. Cement was made to the amount of 4,987,255 barrels as compared with 4,753,033 barrels in 1916.

PORCUPINE.—The labour situation on the whole shows improvement, the unsettled feeling created by the draft having subsided, but in order to maintain full working forces the men have to be paid high wages, as labour is greatly in demand in all lines of industry. The Hollinger and McIntyre are paying wages on a higher scale than prevail elsewhere, which creates some restlessness among the workers. The Dome mill remains closed, and underground work is only being maintained on a limited scale. The shaft is being sunk from the 800 to the 1,000 ft. level. As diamond-drilling has indicated good ore at a lower depth the management intends ultimately to sink to 1,500 ft., in the meantime opening up ore on the 800 ft. level. As the mine cannot pay dividends on $5 ore under present conditions, the management considers it advisable to suspend milling operations until a sufficient quantity of high-grade ore is available. The Dome Extension will resume the diamond-drilling exploration on their property which was begun by the Dome Mines during its option. The Hollinger has completed the installation of its new milling equipment, which is now being tested. When in operation it will add 1,000 tons per day to the mill capacity. The McIntyre is steadily improving its position. The milling capacity is 600 tons per day, and the value of the ore treated is well maintained at about $10 per ton. The main working is being put down to the 1,325 ft. level, and the width and mineralization of the veins is found to increase with depth. The Davidson has ore blocked out down to the 200 ft. level, amounting to 100,000 tons estimated at an average of $10 per ton.

KIRKLAND LAKE.—There is much activity in this district and many new strikes are reported, but a deterrent factor is the considerably higher cost of mining and milling operations as compared with Porcupine. Operating costs are figured at about $10 per ton. A compensating feature is that while a large tonnage will not average over that figure there are long ore-shoots running over $20. It is hoped that with the opening of new mines and increased milling facilities and a restoration of normal economic conditions it may be possible to so reduce operating expenses as to render it feasible to treat profitably $8 and $10 ore. The new mill at the Lake Shore mine is completed and the initial run is being made. The present capacity is 60 tons per day, but provision has been made for adding to the equipment if required. The Tough Oakes has cut a new vein at the 350 ft. level carrying an average gold content of $20 per ton over a width of 6 ft. The Teck Hughes during January treated 2,177 tons of ore of the average value of $8·62 per ton, being a large increase in the output. The shaft on No. 2 vein at the Canadian Kirkland is down 40 ft., at which point the vein is 7 ft. wide with ore stated to average $21 to the ton.

FORT MATACHEWAN.—This new gold district, about 30 miles south-east of Porcupine on the Montreal River, is attracting much attention. The first claims were staked previous to the discovery of silver at Cobalt, and since then little interest was taken until last year, when there was a rush of prospectors and about 1,000 claims were taken up. Latterly capitalists have been looking for investments in the district, and some of the claims have changed hands at high figures. A number of the old Cobalt companies have acquired interests. Buyers associated with the Utah Copper Co. have taken over the Otisse and Davidson claims at prices stated to amount to several hundred thousand dollars. An active season of development will be begun in the spring. The Fort Matachewan district is reached by trail up the Montreal River from Elk Lake, a distance of 38 miles, and can be reached over the same route by canoe in the open season.

CAMBORNE.

BRITISH TUNGSTEN MINES.—Work on this wolfram property situated at Buttern Hill, in the Altarnun district, has been suspended, after a large sum of money, stated to be £30,000, has been expended on plant and buildings. The cause of the suspension is that what was thought to be wolfram proved to be ilmenite. However, there are engineers of standing who still hold the opinion that this is a most promising wolfram prospect, and that the mistake was made in attacking the wrong part of the property where it was known that ilmenite existed. The plant is to be sold shortly.

BASSET.—There has been a serious accident to the pumping plant at Marriott's shaft, and Captain Jopling, the new manager, is to be commiserated on the series of misfortunes that have happened since his appointment.

AT WHEAL KITTY there has been a serious breakage, the polecase of the pitwork having given out, and the principal workings in Sara's section of the property are flooded. This is unfortunate, as the stopes were looking particularly well at the time. Preparations are well forward for the installation of two bucket lifts to fork the water. This is now the only mine working in the parish of St. Agnes, which was once an important and flourishing tin mining centre.

WAGES.—The Ministry of Munitions has recently advised the mining companies that the Coal Controllers award of October 3 last, prescribing an advance in the wages of colliery workers, has by agreement been extended to men engaged in non-ferrous mines, for instance to lead and zinc miners, and that representations have been since received by the Department to the effect that the wages of Cornish tin miners are at a low level and deserve immediate attention. The Department then proceeds to express the opinion that Cornish tin miners cannot reasonably be excluded from the award referred to, and proposes that they should also receive the advances. This letter appears to have been issued without any consultation with either the Unions or the Cornish mining companies, without any knowledge of the condition of the industry, and in complete ignorance of the recent agreement between the companies and the Workers Union for a minimum wage as referred to in my letter of January last. This is a good example of the "butting in" of a Government department, and explains how differences between capital and labour often arise in these times. Surely before any opinion either way was expressed, the Department should have heard both sides and incidentally have ascertained the difficulties from which the majority of the tin mines (as apart from mines producing wolfram and arsenic) are suffering.

PERSONAL.

THOMAS BRENTON has retired from the secretaryship of Johnson, Matthey & Co. Ltd., a position he had held for many years.

DR. H. C. H. CARPENTER, professor of metallurgy at the Royal School of Mines, has been elected a Fellow of the Royal Society.

J. T. DIXON, of the firm of Inder, Henderson, & Dixon, has left for Australia and New Zealand.

R. T. HANCOCK, of the Nigerian Tin Corporation, left London on April 10 for Northern Nigeria.

DR. J. A. LEO HENDERSON has returned from Canada.

C. S. HERZIG has moved his office from Salt Lake City to 27 William Street, New York.

W. L. HONNOLD was recently elected a director of Springs Mines, Limited.

JAMES HORSBURGH, recently manager for the Chillagoe Company, has been appointed assistant general manager at Mount Morgan.

A. E. KITSON, Government Geologist of the Gold Coast, has been made a C.B.E.

MAJOR H. W. LAWS, D.S.O., has been appointed Controller of Mines for the Third Army of the British Expeditionary Forces.

J. MACFARLANE, manager for the Wallis Company, is home from West Africa.

F. DOUGLAS OSBORNE and W. R. H. CHAPPEL were present at the meeting of shareholders of Gopeng Consolidated, held at Redruth on April 3.

PAWLE & BRELICK have moved their office from Balfour House to 4, London Wall Buildings, London, E.C.2.

A. H. POOLE, who was in Siberia inspecting dredging properties, has returned to Sydney.

GUY C. RIDDELL, on his return to America from Port Pirie, has been appointed metallurgical adviser to the United States Tariff Commission.

E. R. SCHOCH has been appointed superintending engineer for the Anglo-French Exploration Co., with headquarters at Johannesburg.

E. GIBBON SPILSBURY is visiting Cuba.

D. P. SUTTIE has been appointed secretary of the Transvaal School of Mines and Technology at Johannesburg.

ERNEST E. THUM has been appointed Western Editor of *Metallurgical and Chemical Engineering*, with offices at Newhouse Building, Salt Lake City.

GEORGE H. THURSTON has returned from India.

A. E. WALLERS has been re-elected president of the Transvaal Chamber of Mines.

L. A. WOMBLE, lately manager of the Witwatersrand Deep, is now with the Union Miniere du Haut Katanga.

We regret to record the death of T. C. CLOUD. He was for many years metallurgist at Wallaroo & Moonta. More recently he was retained by Elliott's Metal Company at Burry Port, South Wales. He was a member of the council of the Institution of Mining and Metallurgy.

GEORGE H. FOSTER, 2nd Lieutenant R. E. (Tunneling Company) was killed in action on March 21.

ASSHETON LEAVER, chairman of the Jos and other Nigerian companies, died on April 3.

TRADE PARAGRAPHS

G. A. HARVEY & CO. (LONDON), LTD., of the Greenwich metal works, makers of perforated metal, have opened a city office at Suffolk House.

DICK, KERR & CO. LTD., of Preston and London, have recently taken over the control of Willans & Robinson, of Rugby, makers of steam turbines and Diesel engines.

THE SULLIVAN MACHINERY CO. announce that the diamond drill order by the South Crofty company has arrived in Cornwall and will start operations shortly.

THE WESTERN WHEELED SCRAPER CO., of Aurora, Illinois, issues a monthly house-organ called the *Earth Mover*. The February issue contains information relating to New York's Catskill water project.

THE BARIO METAL CO., of New York, has placed on the market a series of alloys called "bario." No particulars are given of its constitution, but it is stated to resist the attacks of sulphuric, nitric, and hydrochloric acids and not to rust or tarnish on exposure. The lowest melting point of the series is 3,100° F.

THE HUFF ELECTROSTATIC SEPARATOR CO. announces the opening of an office at 120, Broadway, New York, for consultation regarding ore-dressing problems, especially the dry concentration of ores and the separation of valuable minerals from others that are commercially detrimental.

THE MARION STEAM SHOVEL CO., of Marion, Ohio, send us a small general catalogue indicating the variety of mechanical movers of material with which their name is connected. In addition to steam shovels, they make drag-line excavators, dipper dredges, bucket dredges, and pump dredges.

THE "PYREKS" heat-indicator compounds are a series of metallic salts graduated to have definite melting points and applicable in pyrometry. The pyreks powders are held in spoons made of "reactal" alloy, and are employed in the heat treatment of steel and other alloys. They are placed on the market by Darwin & Milner Ltd., and Sybry, Searls & Co. Ltd., both of Sheffield.

H. J. YATES and S. N. BRAYSHAW, of Essex Works, Aston, Birmingham, and Mulberry Street, Hulme, Manchester, respectively, are introducing a type of gas burner for metallurgical and other furnaces, working with gas at the normal pressure of the main and air at only a few inches pressure. The burner is particularly adapted for furnaces used in hardening and tempering steel.

THE VERDITE MINES, LIMITED, of Johannesburg, is now supplying the whole of South Africa's requirements for talc. During the first six weeks of the current year the sales have been greater than for the whole of 1917. The restrictions in shipping have given the company its opportunity. The credit for the development of the deposits, which are near Barberton, and for the establishment of a trade in the products is primarily due to Mr. T. D. Cunningham. The company is now supplying makers of soap, grease, paints, boots, toilet powders, imitation stone, dolls, rubber, etc., and has started the manufacture of talc slate-pencils, boot-white, metal polish, crayons, modeling clay, etc.

THE NEW YORK ENGINEERING CO. reports that the new dredge which they recently erected in Korea, for the Chiksan Mining Company, went into operation on December 1. The Chiksan Company spent about two years in drilling the placer ground. This work was done by Mr. James J. Martin, of California, using the Empire drill. The contract to build the dredge was accepted in November, 1915, and the dredge was ready for shipment in August, 1916. But there was great difficulty in securing shipping space, which caused a delay, but finally the dredge reached Chiksan and was erected and ready for operation in July, 1917. The Chiksan Company built their own power plant and ordered the boilers from London. There was delay in securing these boilers, and they did not arrive in Korea until October, 1917. Consequently the dredge could not operate, on account of the power plant not being completed, until December 1, 1917. This dredge has 10 cu. ft., all-manganese steel buckets, electrically driven. The steel hull is 50 ft. wide, 110 ft. long, and 10 ft. deep. We hope to be able to give detailed particulars of the construction of this dredge on some future occasion, together with a record of results.

BRUCE PEEBLES & CO., LIMITED, of Edinburgh, have recently made several unusually large 50-cycle motor-converter sets, these indeed being the largest of this type of converter manufactured in Great Britain. These have been supplied to the municipalities of Sydney, Johannesburg, and Manchester. The largest was that sent to Manchester, which has a capacity of 2,200 kilowatts. Another, to have a capacity of 2,400 k.w., has recently been ordered for the same city to supplement that already at work. A short description of the 2,000 k.w. set sent to Sydney will be of interest. The machine runs at 300 r.p.m. and is arranged with three pedestal bearings. The bedplate is split longitudinally, the facings being carefully machined and bolted together. Barring gear is provided for barring round the rotating element for cleaning or other purposes when the machine is not in operation. The alternate current supply, which is switched direct on to the stator, is 3 phase 50 cycles 5,000 volts, and the continuous current end, which is shunt-wound, gives its output at 485–540 volts. Owing to the heavy continuous current, namely 4,125 amperes, the direct current end has a double commutator, and the brush gear, which is carried from the bedplate, is of particularly substantial construction. The machine is designed to deal continuously with an out-of-balance current equal to 25% of normal full load, that is, about 1,000 amperes, and with this out-of balance current the voltage difference between the two halves will not be more than 1% of the voltage across the outers. This particular set, for special reasons, is started up from the direct current end by means of a multiple-lever starter, which is short-circuited with a 4,000 ampere heavy laminated short-circuiting switch after the machine has been run up to speed. When it is installed the starter will be mounted on the bedplate between the alternating current and direct current machines. The alternating current rotor is provided with slip-rings and the usual short-circuiting gear, which latter is brought into use after the rotating element has commenced to revolve; but in the event of the machine ever having to be started from the alternating current end, the slip-rings and short-circuiting gear will come into operation in the usual way for alternating current starting. In any case, however, motor-converter slip-rings are always of small diameter and section, as they are only in use at starting and in three-wire machines to collectively carry the out-of-balance current. The guaranteed efficiencies are 93·5% at full load, 93·25% at three-quarter load, and 92·5% at half load. The temperature rise will not exceed 70° F. after six hours full-load run and, when supplied with alternating current at 5,000 volts and with the direct current voltage at 505, the power factor will be unity at 90% of full load; at 540 volts and full load the power factor will be 0·97 leading, while at 485 volts and full load it will be 0·98 lagging.

METAL MARKETS

COPPER.—There is no change in the official prices, which are maintained at £110 to £110. 10s. for standard, and £125 to £121 for electrolytic. In America 23½ cents is officially quoted for electrolytic. Some further discussion is taking place as to the need for raising the official price owing to the necessity of stimulating an increase of output in view of the demand, which for a long time to come is likely to continue for the metal, both for military purposes during the war, and for ordinary industrial purposes afterward. Mainly owing to a growing economy in the use of the metal, supplies have been ample to meet all demands. Delays in transport have also restricted consumption, and a cutting of the official price of 24·67½ cents for less than car-load lots is reported. Against this must be placed the fact that the smelters' costs have risen to the extent of about $7 per ton, and that owing to the excessive transport difficulties it is necessary for them at present to finance five or six months output. It is generally assumed that 25 cents would be effective in keeping up the necessary supply, and there is a growing belief that the official figure will be raised to this level when the time comes for revision.

Average prices of cash standard copper: March 1918, £110. 5s.; February 1918, £110. 5s.; March 1917, £137. 1s. 2d.

TIN. — Control of this market has been taken over on behalf of the Government by a committee of the London Metal Exchange, who regulate prices and apportion supplies to the different consumers in proportion to the importance of their consumption and the urgency of their work. Prices have been actually little affected by the new conditions of sale, except that it is undoubted that a threatened considerable increase of values has been prevented. At the end of March the price was fixed at £316 as against the highest cash price of £320 during the month. For February the statistics disclosed an increase in visible supply of 479 tons, but as these figures are partly based upon estimates they afford no great indication of market prospects, and it is significant that excluding metal afloat to the United States there is a decrease in supplies. Stocks in this country have shrunk to a very low level, and with the object of conserving these for our own uses the granting of export licences has been suspended. Several good parcels have just recently reached port, so that stocks will be replenished in the warehouses within a short time. American values are maintained at a high level, and it is satisfactory that large quantities are on the way there. A run on English tin has taken place owing to greater facilities being given for the purchase of these grades, and smelters are consequently very full of orders; immediate delivery is difficult, and full prices are being realized. London Straits is at a premium of 30s. to £2.

Average prices of cash standard tin: March 1918, £318. 15s.; February 1918, £311. 12s. 3d.; March 1917, £207. 10s. 8d.

LEAD.—Prices have not changed at £29. 10s. to £28. 10s. net, the equivalent of £30. 10s. 5d. to £29. 9s. 9d. full terms. In America prices have steadily declined from 7·62½ to 7·20 cents. Japan has been in the market for small parcels.

Average prices for soft foreign lead: March 1918, £29; February 1918, £29; March 1917, £30.

SPELTER.—Official prices in this country are unchanged at £54 to £50. Inquiry is small and business unimportant. In America the market has been easy and buyers shy. Very little business has been done, and quotations have fallen to 7 cents.

Average prices of good ordinary brands: March 1918, £52; February 1918, £52; March 1917, £54. 10s. 4d.

ALUMINIUM—£225 per ton. NICKEL—£220 per ton.

ANTIMONY. — English regulus £85 per ton; crude £46 per ton.

QUICKSILVER.—£22 per flask of 75 lb.

BISMUTH.—12s. 6d. per lb. CADMIUM.—8s. per lb.

PLATINUM.—New 400s. per oz.; scrap 360s.

MOLYBDENITE.—90% MoS_2, 105s. per unit.

WOLFRAM.—65–70% WO_3, 60s. per unit.

SILVER. — The quotation has continued high and fairly steady. The American Government has fixed the price at $1·00 per oz. fine.

PRICES OF CHEMICALS April 10

Owing to the war, buyers outside the controlled firms have a difficulty in securing supplies of many chemicals, and the prices they pay are often much higher than those quoted below.

		£	s.	d.
Alum	per ton	18	10	0
Alumina, Sulphate of	,,	18	10	0
Ammonia, Anhydrous	per lb.		1	10
,, 0·880 solution	per ton	34	0	0
,, Chloride of, grey	per cwt.	2	7	0
,, ,, ,, pure	,,	4	0	0
,, Nitrate of	per ton	75	0	0
,, Phosphate of	,,	125	0	0
,, Sulphate of	,,	15	10	0
Arsenic, White	,,	130	0	0
Barium Sulphate	,,	9	0	0
Bleaching Powder, 35% Cl.	,,	14	0	0
Borax	,,	37	0	0
Copper, Sulphate of	,,	67	0	0
Cyanide of Sodium, 100%	per lb.		1	0
Hydrofluoric Acid	,,			7
Iodine	,,		14	0
Iron, Sulphate of	per ton	16	0	0
Lead, Acetate of, white	,,	150	0	0
,, Nitrate of	,,	65	0	0
,, Oxide of, Litharge	,,	42	0	0
,, White	,,	46	0	0
Magnesite, Calcined	,,	14	0	0
Magnesium Sulphate	,,	11	0	0
Phosphoric Acid	per lb.		1	4
Potassium Carbonate	per ton	200	0	0
,, Chlorate	per lb.		2	3
,, Chloride 80%	per ton	60	0	0
,, Hydrate, (Caustic) 90%	,,	400	0	0
,, Nitrate	,,	70	0	0
,, Permanganate	per lb.		14	0
,, Prussiate, Yellow	,,		3	6
,, Sulphate, 90%	per ton	65	0	0
Sodium Metal	per lb.		1	8
,, Acetate	per ton	115	0	0
,, Bicarbonate	,,	8	10	0
,, Carbonate (Soda Ash)	,,	7	0	0
,, ,, (Crystals)	,,	4	5	0
,, Hydrate, 76%	,,	26	0	0
,, Hyposulphite	,,	52	0	0
,, Nitrate, 95%	,,	27	0	0
,, Phosphate	,,	60	0	0
,, Silicate	,,	7	0	0
,, Sulphate (Salt-cake)	,,	2	12	6
,, ,, (Glauber's Salts)	,,	3	10	0
,, Sulphide	,,	45	0	0
Sulphur, Roll	,,	21	0	0
,, Flowers	,,	23	0	0
Sulphuric Acid, non-arsenical 144°T.	,,	4	5	0
,, non-arsenical 95%	,,	7	0	0
Superphosphate of Lime, 18%	,,	5	0	0

STATISTICS.

Production of Gold in the Transvaal.

	Rand	Elsewhere	Total	Value
	Oz.	Oz.	Oz.	£
Year 1912	8,753,563	370,731	9,124,299	38,757,560
Year 1913	8,430,998	363,826	8,794,824	37,358,040
Year 1914	8,033,567	344,570	8,378,139	35,588,075
Year 1915	8,772,919	320,752	9,073,671	38,627,461
Year 1916	8,971,359	324,179	9,295,538	39,484,934
January 1917	756,997	25,637	782,634	3,324,418
February	696,955	24,366	721,321	3,063,976
March	760,598	26,496	787,094	3,343,363
April	717,598	25,180	742,778	3,155,121
May	753,531	26,034	779,385	3,310,618
June	732,799	26,925	759,724	3,227,101
July	731,848	25,991	757,839	3,219,094
August	731,405	25,253	756,658	3,214,079
September	712,881	25,350	738,231	3,135,807
October	724,846	26,444	751,290	3,191,279
November	698,271	24,568	722,839	3,070 426
December	697,137	25,282	722,419	3,068,639
Year 1917	8,714,866	307,527	9,022,493	38,323,921
January, 1918	694,121	19,991	714,182	3,033,653
February	637,571	22,188	659,759	2,802,477

Natives Employed in the Transvaal Mines.

	Gold mines	Coal mines	Diamond mines	Total
January 31, 1917	188,624	11,611	5,591	205,826
February 28	191,095	11,568	6,268	208,931
March 31	190,028	11,494	6,620	208,142
April 30	185,975	11,435	6,314	203,724
May 31	180,168	11,432	5,805	197,405
June 30	175,727	11,258	5,369	192,354
July 31	171,653	11,381	5,223	188,257
August 31	170,817	11,401	5,028	187,246
September 30	171,334	11,601	4,791	187,726
October 31	170,531	11,841	4,620	186,792
November 30	169,083	11,633	4,620	185,336
December 31	172,740	11,695	4,593	189,028
January 31, 1918	176,424	11,469	4,715	192,608
February 28	181,066	11,243	4,825	197,134

Cost and Profit on the Rand.

Compiled from official statistics published by the Transvaal Chamber of Mines. The profit available for dividends is about 60% of the working profit.

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
January 1917	2,337,066	26 10	18 8	7 11	941,520
February	2,153,691	27 3	19 2	7 10	841,259
March	2,430,590	26 7	19 0	7 4	879,351
April	2,235,833	27 2	19 2	7 8	857,710
May	2,405,855	26 4	18 7	7 5	887,527
June	2,288,426	26 11	19 2	7 7	867,639
July	2,294,668	26 11	19 0	7 7	869,577
August	2,301,892	26 9	19 0	7 6	859,517
September	2,195,884	27 5	19 4	7 9	848,096
October	2,280,461	26 10	19 5	7 2	814,211
November	2,156,814	27 4	19 11	7 2	775,502
December	2,130,510	27 7	20 0	7 4	783,729

Production of Gold in Rhodesia and West Africa.

	Rhodesia.		West Africa.	
	1917	1918	1917	1918
	£	£	£	£
January	296,113	253,807	131,665	107,863
February	289,734	232,023	104,892	112,865
March	300,183	—	158,727	—
April	297,977	—	123,825	—
May	299,271	—	121,104	—
June	302,195	—	114,489	—
July	288,731	—	142,017	—
August	294,359	—	130,278	—
September	291,367	—	127,168	—
October	289,978	—	126,295	—
November	275,829	—	126,915	—
December	270,616	—	122,602	—
Total	3,495,391	485,830	1,529,977	220,728

West Australian Gold Statistics.

	Reported for Export oz.	Delivered to Mint oz.	Total oz.	Total value £
January 1917	*	83,962	*	*
February	*	81,810	*	*
March	*	76,171	*	*
April	*	82,144	*	*
May	*	78,165	*	*
June	*	82,600	*	*
July	*	81,166	*	*
August	*	80,181	*	*
September	*	81,761	*	*
October	*	73,901	*	*
November	*	80,642	*	*
December	*	78,793	*	*
January, 1918	*	73,703	*	*
February	*	76,987	*	*
March	*	69,730	*	*

* By direction of the Federal Government the export figures will not be published until further notice.

Australian Gold Returns.

	Victoria.		Queensland.		New South Wales	
	1916	1917	1917	1918	1917	1918
	£	£	£	£	£	£
January	89,900	67,627	50,150	47,600	29,000	25,000
February	76,500	65,450	63,200	45,470	26,000	28,000
March	103,600	74,794	61,200	—	41,000	—
April	60,000	75,139	62,470	—	21,000	—
May	119,500	65,623	65,450	—	28,400	—
June	86,000	64,180	73,100	—	24,600	—
July	100,600	68,937	71,820	—	44,000	—
August	66,800	101,428	74,800	—	21,000	—
September	115,100	61,701	64,180	—	20,000	—
October	81,400	33,533	54,400	—	47,000	—
November	94,000	75,912	42,380	—	29,000	—
December	96,600	56,967	64,170	—	19,000	—
Total	1,090,000	846,540	780,720	93,070	349,000	53,000

Production of Gold in India.

	1915	1916	1917	1918
	£	£	£	£
January	201,255	192,150	190,047	176,030
February	195,970	183,264	180,904	173,343
March	194,350	186,475	189,618	177,950
April	196,747	192,208	185,835	—
May	199,786	193,604	184,874	—
June	197,447	192,469	182,426	—
July	197,056	191,404	179,660	—
August	197,984	192,784	181,005	—
September	195,952	192,330	183,630	—
October	195,531	191,502	182,924	—
November	192,714	192,298	182,388	—
December	204,590	205,164	190,852	—
Total	2,369,382	2,305,652	2,214,163	527,323

Daily London Metal Prices

Copper, Lead, Zinc, Tin, in £ per long ton. Silver in pence per standard ounce.

	Copper			Soft For'n Lead	Zinc	Tin Standard	Silver
	Standard	Electrolytic	Best Select'd				
Mar.	£	£	£	£ s.	£ s.	£ s. d.	d.
13	110	125	123	29 10	54 0	322 0 0	43
14	110	125	123	29 10	54 0	322 0 0	43
15	110	125	123	29 10	54 0	320 0 0	43
18	110	125	123	29 10	54 0	320 0 0	43¼
19	110	125	123	29 10	54 0	320 0 0	43¼
20	110	125	123	29 10	54 0	318 0 0	43¾
21	110	125	123	29 10	54 0	318 0 0	44½
22	110	125	123	29 10	54 0	316 0 0	45
25	110	125	123	29 10	54 0	316 0 0	46
26	110	125	123	29 10	54 0	316 0 0	45⅝
27	110	125	123	29 10	54 0	316 0 0	45⅝
28	110	125	123	29 10	54 0	316 0 0	45⅝
April							
2	110	125	123	29 10	54 0	316 0 0	45⅝
3	110	125	123	29 10	54 0	316 0 0	45⅝
4	110	125	123	29 10	54 0	316 0 0	45½
5	110	125	123	29 10	54 0	316 0 0	45½
8	110	125	123	29 10	54 0	318 0 0	45¼
9	110	125	123	29 10	54 0	320 0 0	45¼
10	110	125	123	29 10	54 0	322 0 0	45¼

Imports of Ores and Metals into United Kingdom.

These figures now include Government imports.

* Statistics not published. Long tons.

	Year 1917	Feb. 1918	Year 1918
	Tons	Tons	Tons
Iron Ore	*	*	*
Copper Ore	*	*	*
,, Matte and Precipitate	28,241	2,100	4,326
,, Metal	142,778	12,497	33,533
Copper and Iron Pyrite	*	*	*
Tin Concentrate	*	*	*
,, Metal	27,143	697	3,844
Manganese Ore	*	*	*
Lead, Pig and Sheet	147,124	17,989	41,838
Zinc (spelter)	76,105	3,365	14,346
	lb.	lb.	lb.
Quicksilver	2,172,434	44,925	304,275

Exports of Copper from United States

1917	Long tons	1917	Long tons	1918	Long tons
January	25,540	July	38,127	January	37,000
February	24,937	August	45,304	February	—
March	51,246	September	30,493	March	—
April	79,001	October	39,115	April	—
May	45,241	November	38,638	May	—
June	39,816	December	35,000	June	—
Total	265,783	Total 1917	484,120	Total 1918	37,000

Outputs of Tin Mining Companies.

In Tons of Concentrate.

	Year 1917	Feb. 1918	Year 1918
	Tons	Tons	Tons
Bisichi (Nigeria)	278	30	60
Briseis (Tasmania)	237	29	59
Dolcoath (Cornwall)	863	68	136
East Pool (Cornwall)*	1,012	102	194
Gopeng (F.M.S.)	1,039	71	152
Malayan Tin (F.M.S.)	828	47	109
Mongu (Nigeria)	571	50	85
Naraguta (Nigeria)	503	47	92
N. N. Bauchi (Nigeria)	550	45	95
Pahang (F.M.S.)	2,612	157	331
Rayfield (Nigeria)	660	65	130
Renong (Siam)	1,023	73	130
Siamese Tin (Siam)	808	77	221
South Crofty (Cornwall)*	694	55	115
Tekka-Taiping (F.M.S.)	422	21	42
Tongkah Harbour (Siam)	1,229	80	205
Tronoh (F.M.S.)	1,046	96	200

* Including Wolfram.

Stocks of Tin.

Reported by A. Strauss & Co. Long tons.

	Jan. 31, 1918	Feb. 28, 1918	March 31, 1918
	Tons	Tons	Tons
Straits and Australian, Spot	3,099	2,228	1,190
Ditto, Landing and in Transit	400	475	—
Other Standard, Spot and Landing	498	482	438
Straits, Afloat	*4,085	*3,370	*5,000
Australian, Afloat	—	—	—
Banca, on Warrants	—	—	—
Ditto, Afloat	*2,300	*2,900	*3,655
Billiton, Spot	—	—	—
Ditto, Afloat	*300	*300	*300
Straits, Spot in Holland and Hamburg	—	—	—
Ditto, Afloat to Continent	*500	*500	*500
Afloat for United States	*7,579	*9,555	*9,246
Stock in America	767	197	134
Total Stock	19,528	20,007	20,463

* Estimated.

Shipments and Imports of Tin

Reported by A. Strauss & Co. Long tons.

	Year 1916	Year 1917	March 1918	Year 1918
	Tons	Tons	Tons	Tons
Shipments from:				
Straits to U.K.	27,157	28,099	*2,500	*,5000
Straits to America	25,943	24,977	*2,000	*8,500
Straits to Continent	8,487	9,290	*500	*1,150
Australia to U.K.	2,537	349	—	—
U.K. to America	14,863	12,890	60	808
Imports of Bolivian Tin into Europe	15,116	19,209	937	3,231
Deliveries in U.K.	16,862	15,142	1,782	4,716
,, ,, Holland	943	1,714	—	*71

* Estimated.

Nigerian Tin Production.

In long tons of concentrate of unspecified content.

Note. These figures are taken from the monthly returns made by individual companies reporting in London, and probably represent 85% of the actual outputs.

	1913	1914	1915	1916	1917	1918
	Tons	Tons	Tons	Tons	Tons	Tons
January	466	485	417	531	667	666
February	427	469	358	528	646	641
March	510	502	418	547	655	—
April	430	482	444	486	555	—
May	360	480	357	536	509	—
June	321	460	373	510	473	—
July	357	432	455	506	479	—
August	406	228	438	498	551	—
September	422	289	442	535	538	—
October	480	272	511	584	578	—
November	446	283	467	679	621	—
December	478	326	533	654	655	—
Total	5,103	4,708	5,213	6.594	6,927	1,307

Production of Tin in Federated Malay States.

Estimated at 70% of Concentrate shipped to Smelters.
Long Tons. No figures published since June, 1917.

	1913	1914	1915	1916	1917
	Tons	Tons	Tons	Tons	Tons
January	4,121	4,983	4,395	4,316	3,558
February	3,823	3,555	3,780	3.372	2,755
March	3,562	3,839	3,653	3,696	3,286
April	4,066	4,087	3,619	3,177	3,251
May	4,319	4,135	3,823	3.729	3,413
June	3,993	4,303	4,048	3,435	3,489
July	4,245	4,582	3,544	3.517	...
August	4,620	3,591	4,046	3,732	...
September	4,379	3,623	3,932	3,636	...
October	4,409	3,908	3,797	3,681	...
November	3,976	4,085	4,059	3,635	...
December	4,614	4,351	4,071	3,945	...
	50,127	49,042	46,767	43,871	19,752

Sale of Tin Concentrate at Redruth Ticketings.

	Long tons	Value	Average
July 2, 1917	159½	£21,661	£135 16 1
July 16	144½	£18,896	£130 19 11
July 30	168	£23,225	£138 5 0
August 13	160¼	£21,757	£135 15 4
August 27	156½	£21,429	£136 18 6
September 10	160¼	£21,784	£135 18 9
September 24	153	£21,448	£140 3 9
October 8	160½	£22,160	£138 11 6
October 22	153	£21,712	£141 18 2
November 6	144½	£21,063	£146 0 5
November 19	156	£24,737	£158 11 6
December 3	148	£24,609	£165 5 6
December 17	148½	£25,620	£172 10 7
December 31	151¾	£23,450	£154 10 8
Total, 1917	4,186	£561,003	£134 0 0
January 14, 1918	141	£23,563	£167 2 3
January 28	171½	£28,976	£168 19 2
February 11	166½	£29,674	£178 4 6
February 25	156½	£28,213	£180 18 4
March 11	178¼	£33,398	£187 7 4
March 25	169½	£31,253	£184 7 9

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS:	April 5, 1917 £ s. d.	April 5, 1918 £ s. d.
Rand:		
Bantjes	6 6	3 6
Brakpan	5 0 6	4 15 0
Central Mining (£8)	6 7 6	5 17 6
Cinderella	4 3	4 0
City & Suburban (£4)	1 14 6	17 6
City Deep	4 6 3	2 15 6
Consolidated Gold Fields	1 9 6	1 15 0
Consolidated Langlaagte	1 5 6	16 6
Consolidated Main Reef	17 3	15 6
Consolidated Mines Selection (10s.)	1 3 3	1 11 0
Crown Mines (10s.)	2 11 3	1 10 0
Daggafontein	12 6	1 7 0
D. Roodepoort Deep	11 3	10 0
East Rand Proprietary	10 0	5 0
Ferreira Deep	1 3 9	13 9
Geduld	2 3 9	1 18 9
Geldenhuis Deep	1 1 3	13 9
Gov't Gold Mining Areas	2 18 0	3 11 3
Heriot	2 0 0	1 7 6
Jupiter	6 3	5 0
Kleinfontein	1 2 3	19 0
Knight Central	8 0	4 0
Knight's Deep	1 1 3	9 6
Langlaagte Estate	16 0	13 6
Meyer & Charlton	5 1 3	4 18 9
Modderfontein (£4)	19 12 6	22 10 0
Modderfontein B	7 11 3	7 7 6
Modder Deep	6 16 3	7 1 3
Nourse	1 2 6	18 9
Rand Mines (5s.)	3 7 0	2 11 3
Rand Selection Corporation	3 11 3	4 10 0
Randfontein Central	13 6	11 6
Robinson (£5)	16 3	15 6
Robinson Deep A (1s.)	1 10 0	1 1 3
Rose Deep	19 6	18 0
Simmer & Jack	5 9	5 0
Simmer Deep	4 0	3 0
Springs	2 18 9	3 13 9
Sub-Nigel	1 8 9	1 5 6
Van Ryn	1 16 3	1 0 0
Van Ryn Deep	3 4 6	3 9 6
Village Deep	1 5 6	19 6
Village Main Reef	14 9	12 0
Witwatersrand (Knight's)	2 3 9	1 6 3
Witwatersrand Deep	17 6	8 0
Wolhuter	10 3	5 6
Other Transvaal Gold Mines:		
Glynn's Lydenburg	14 6	18 9
Sheba (5s.)	1 3	9
Transvaal Gold Mining Estates	17 0	17 0
Diamonds in South Africa:		
De Beers Deferred (£2 10s.)	13 5 0	12 12 6
Jagersfontein	4 8 9	4 6 3
Premier Deferred (2s. 6d.)	7 10 0	7 0 0
Rhodesia:		
Cam & Motor	7 3	11 0
Chartered British South Africa	12 0	15 0
Eldorado	8 0	6 6
Falcon	14 6	1 2 0
Gaika	9 0	15 0
Giant	5 3	7 6
Globe & Phœnix (5s.)	1 11 3	1 10 6
Lonely Reef	1 1 9	1 12 6
Rezende	15 0	4 0 0
Shamva	1 3 0	1 12 6
Wanderer (3s.)	1 3	1 6
Willoughby's (10s.)	4 0	5 0
West Africa:		
Abbontiakoon (10s.)	5 0	4 0
Abosso	7 0	7 6
Ashanti (4s.)	19 6	1 0 0
Prestea Block A	5 9	3 9
Taquah	17 0	16 0
West Australia:		
Associated Gold Mines	3 0	3 6
Associated Northern Blocks	2 9	2 6
Bullfinch	2 3	2 0
Golden Horse-Shoe (£5)	1 17 0	2 0 0
Great Boulder Proprietary (2s.)	10 9	12 3
Great Boulder Perseverance	1 3	—
Great Fingall (10s).	1 0	1 9
Ivanhoe (£5)	2 2 6	1 15 0
Kalgurli	8 6	9 0
Sons of Gwalia	14 3	9 3

GOLD, SILVER, *cont.*	April 5, 1917 £ s. d.	April 5, 1918 £ s. d.
Others in Australasia:		
Mount Boppy, New South Wales	6 0	7 6
Talisman, New Zealand	7 6	15 0
Waihi, New Zealand	1 12 9	1 16 0
Waihi Grand Junction, New Z'lnd	14 9	16 0
America:		
Alaska Treadwell (£5), Alaska	2 15 0	12 0
Buena Tierra, Mexico	9 6	12 6
Camp Bird, Colorado	6 6	5 6
Casey Cobalt, Ontario	6 6	9 3
El Oro, Mexico	7 0	9 0
Esperanza, Mexico	8 6	9 9
Frontino & Bolivia, Colombia	12 0	12 6
Le Roi No. 2 (£5), British Columbia	8 6	7 0
Mexico Mines of El Oro, Mexico	4 2 6	5 5 0
Oroville Dredging, California	16 0	18 6
Plymouth Consolidated, California	1 2 0	1 2 6
St. John del Rey, Brazil	15 0	16 9
Santa Gertrudis, Mexico	10 0	13 3
Tomboy, Colorado	19 6	17 6
Russia:		
Lena Goldfields	2 0 0	1 5 0
Orsk Priority	1 2 6	13 9
India:		
Champion Reef (2s. 6d.)	5 9	5 3
Mysore (10s.)	3 1 3	2 16 3
Nundydroog (10s.)	1 5 0	1 4 0
Ooregum (10s.)	1 0 6	18 9

COPPER:

Arizona Copper (5s.), Arizona	2 3 9	2 7 6
Cape Copper (£2), Cape Province	4 2 6	2 15 0
Chillagoe (10s.), Queensland	3	1 0
Cordoba (5s.), Spain	5 6	2 0
Great Cobar (£5), N.S.W.	2 3	2 0
Hampden Cloncurry, Queensland	1 12 6	1 8 0
Kyshtim, Russia	2 11 3	17 6
Messina (5s.), Transvaal	10 6	8 0
Mount Elliott (£5), Queensland	5 10 0	3 10 0
Mount Lyell, Tasmania	1 6 6	1 8 0
Mount Morgan, Queensland	1 16 3	1 12 0
Rio Tinto (£5), Spain	63 10 0	64 0 0
Sissert, Russia	1 6 3	17 6
Spassky, Russia	2 0 0	1 0 0
Tanalyk, Russia	2 5 0	17 6
Tanganyika, Congo and Rhodesia	2 7 6	3 3 9

LEAD-ZINC:

Broken Hill:		
Amalgamated Zinc	1 12 0	1 9 6
British Broken Hill	1 7 9	2 1 0
Broken Hill Proprietary (8s.)	2 5 6	3 8 6
Broken Hill Block 10 (£10)	1 4 6	1 15 6
Broken Hill North	2 9 6	2 19 6
Broken Hill South	8 3 9	10 5 0
Sulphide Corporation (15s.)	1 5 3	1 7 0
Zinc Corporation (10s.)	16 0	1 0 0
Asia:		
Burma Corporation	3 16 3	4 5 0
Irtysh Corporation	2 3 0	19 6
Russian Mining	1 1 3	10 0
Russo-Asiatic	5 2 6	2 5 0

TIN:

Aramayo Francke, Bolivia	1 12 6	1 17 6
Bisichi, Nigeria	13 6	15 3
Briseis, Tasmania	4 9	5 6
Dolcoath, Cornwall	10 9	11 6
*East Pool, Cornwall	1 16 3	1 12 3
Ex-Lands Nigeria (2s.), Nigeria	1 6	2 6
Geevor (10s.) Cornwall	13 3	1 3 6
Gopeng, Malay	1 8 9	1 17 6
Ipoh Dredging, Malay	15 6	16 6
Malayan Tin Dredging, Malay	1 18 9	2 2 6
Mongu (10s.), Nigeria	11 6	16 6
Naraguta, Nigeria	15 0	17 6
N. N. Bauchi Pref. (10s.), Nigeria	9 6	12 9
Pahang Consolidated (5s.), Malay.	11 6	12 9
Rayfield, Nigeria	7 3	13 6
Renong Dredging, Siam	2 3 9	2 5 6
Ropp (4s.), Nigeria	17 6	1 2 0
Siamese Tin, Siam	2 3 9	3 1 3
South Crofty (5s.), Cornwall	19 3	2 9 6
Tekka, Malay	3 0 0	3 12 6
Tekka-Taiping, Malay	2 17 6	3 15 0
Tronoh, Malay	1 7 6	1 13 9

* £1 shares split into 4 of 5s. each in August 1917.

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also reviews of new books, and abstracts of the yearly reports of mining companies.

ROSSI AND TITANIUM.

As mentioned last month the Perkin Medal for 1918 has been awarded by the New York Section of the Society of Chemical Industry to Dr. Auguste J. Rossi in acknowledgment of his services to practical science in connection with the smelting of titaniferous iron ores and the metallurgy of titanium, its alloys, and compounds. We quote herewith from the presentation address delivered by Mr. F. A. J. FitzGerald and from Dr. Rossi's speech in reply.

Mr. FitzGerald said that in 1855, at the early age of 16, Rossi graduated from the University of France with the degree of Bachelier ès Sciences et Lettres, and four years later, after he had also graduated from the Ecole Centrale of Arts and Manufactures, where his studies covered mechanical, civil, aud metallurgical work, he came to New York. Here he obtained a position as assistant engineer with the Morris & Essex Railway. Next he was engaged in building a railway to the Boonton Iron Works, but when Fuller, Lord & Co., the proprietors, found that he had studied chemistry and metallurgy they put him in charge of a laboratory at the iron works. It was here that Rossi's attention was first called to titanium, for the ores used in the blast-furnaces at the iron works were magnetites from Morris County, New Jersey, containing in the best samples about 1% of titanic oxide and in others 2·5% or more. Beyond noting the existence of titanium in the ores Rossi was not particularly interested in it until he met the work of Professor Cook, the state geologist of New Jersey. This work called attention to the existence of titanium in nearly all the New Jersey ores, from fractions of 1% to as high as 15% titanic oxide. Professor Cook also established a relation between phosphorus and titanium in the ores, low phosphorus apparently going with high titanic oxide content. This set Rossi to work hunting up all the scanty —and, incidentally, very contradictory—literature he could find on the subject of titanium. None of this work was of any practical importance so far as the running of the Boonton works was concerned, but several years after he had left his metallurgical work to devote his attention to tests on the pumping engines at Fall River, to calculations of the stability of the Beaver Bridge dam, to work on refrigeration and the manufacture of ice-making machinery, his researches on titanium became of value, because of a lawsuit in relation to iron produced at the Boonton Iron Works.

In 1876 the death of the two owners had forced the closing of the Boonton Iron Works, but in the 80's Mr. Eckert, who was making, at Reading, Pennsylvania, what is called stove iron, decided to use the puddled cinders, of which there were years of accumulation, with some of the ores containing 2% TiO_2, leased the two blast-furnaces at Boonton. He made a failure of this run and tried to get out of the contract binding him to use a stipulated number of puddled cinders and ores by claiming that the presence of TiO_2 in the cinders and ores had been the cause of his failure. Hence the lawsuit referred to. Rossi had no difficulty to prove by his books of analyses that the presence of TiO_2 to the extent of Mr. Eckert's analyses was in no way greater than the amounts which had ruled during Rossi's eleven years' practice, and had been found to have had absolutely no effect on the working of the same furnaces. Mr. Eckert had to compromise and pay a heavy forfeit.

This lawsuit was of great importance so far as Rossi's future work was concerned, as it no doubt established his reputation as an expert in the smelting of titaniferous iron ores. Thus, after Rossi had established an office in New York as a consulting engineer, and when in 1890 James McNaughton was interested in the development of the immense titaniferous ore deposits of the Adirondacks, it was to Rossi that he went for advice. Since that date Rossi has devoted most of his time to titanium.

The problem presented in this case was a study of the feasibility of smelting the titaniferous ores of the Adirondacks. Rossi, as a result of his researches years before, was well acquainted with what had been done in Europe in this direction, and of special interest were the records he had of some blast-furnaces near Stockton-on-Tees, where ores running as high as 35% titanic oxide had been smelted successfully by forming a slag that consisted of a silico-titanate of lime. This, of course, involved adding considerable quantities of lime and silica to the charge. Here lay the great objection to the Stockton-on-Tees practice, for on account of the low iron content of the ore it was necessary to make about four tons of slag for one ton of iron. Rossi told his client that success with the Adirondack ores could be obtained provided that the titanic oxide could be slagged off without using an enormous excess of fluxes, and that so far as the pig iron produced was concerned it would probably be of a very superior quality. The upshot of the consultation was that Rossi went to examine the ore deposits and two small blast-furnaces which had been run there by Mr. MacNaughton's grandfather from 1840 to 1858. Rossi studied the blast-furnace records, and knowing the composition of the ore, the fluxes added, and the amounts of these going into the charges of the old blast-furnaces, he found that the practice of the Stockton-on-Tees furnaces had been anticipated. He also found that the iron produced was of such superior quality that a gold medal had been awarded it in the great London Exhibition of 1851. Moreover, certain steel made from this iron won high commendation from the navy yards of Springfield and Washington, the report stating that it compared favourably with the best Swedish steel. Rossi then began a series of experiments on slags with the object of replacing silica with titanic oxide in the normal blast-furnace slag, and following his success in this direction, built what might be described as a laboratory blast-furnace in which several hundred pounds of excellent pig iron was made from the titaniferous iron ores. In this way Rossi did the pioneer work in demonstrating the value of the great ore deposits of the Adirondacks in 1894. Twenty years later we find this work confirmed by Frank E. Bachman, general manager of the MacIntyre Iron Company, Port Henry, New York, in an interesting paper, "The

Use of Titaniferous Ore in the Blast-Furnace," presented to the American Iron and Steel Institute, October, 1914.

With regard to ferro-titanium, Rossi was convinced from what he had observed in the work on smelting titaniferous ores that titanium had a beneficial effect on the manufacture of iron. A natural deduction from this was that an alloy of iron and titanium would be of value for the treatment of iron and steel in the process of manufacture. This led to a series of experiments in small electric furnaces, and finally to the construction of larger furnaces at Niagara Falls in 1899, where considerable quantities of ferro-titanium were manufactured, thus permitting of a great number of tests being made on a large scale in steel works and foundries. This may be considered as closing the experimental period in the development of the manufacture and use of ferro-titanium. Rossi had now convinced himself of its value, and the next problem was the education of others in its use. While the value of ferro-titanium has always been recognized by some, there existed for a long time a prejudice against it in the minds of many, and in some quarters this exists even to-day.

Dr. Rossi in his reply, gave many reminiscences. We quote part of his speech as follows:

"About 1900 I started making ferro-titanium at Niagara Falls by reducing titaniferous iron ores in an electric arc furnace. I used preferably those ores containing the highest percentages of TiO_2, such as ilmenite containing 40% TiO_2 and 50% more or less oxide of iron, or even rutile containing 93 to 95% TiO_2. The furnace, being made of a masonry of graphitic material, formed the cathode, and a carbon electrode, which was movable vertically by means of a mechanical device, or automatically by the current itself, formed the anode. A properly comminuted mixture of the titaniferous material and of the carbon required for reduction of both TiO_2 and oxide of iron was charged gradually into the furnace as the current was turned on. Whenever the relative proportion of TiO_2 and oxide of iron were such as to produce an alloy higher in titanium than was desired, some scrap iron was charged with the mixture. In this manner I made alloys containing from 10% to 25% or more, but practice in steel and other works has shown that an alloy containing about 15% of titanium was best suited for most purposes.

"Whenever the presence of carbon in the ferro-carbon-titanium was considered objectionable for special applications, I reduced the titaniferous materials by my aluminium-bath process. Instead of using a mixture of finely powdered aluminium and titaniferous material, as in Goldschmidt's thermit process, the aluminium I used for the reduction of the oxides was melted in the electric furnace and the titaniferous materials charged directly into the bath. In such cases I used preferably TiO_2 as rutile in order to avoid using the aluminium which would have been required for the reduction of the oxide of iron of the ore, charging scrap iron with the rutile to dilute the alloy to the desired content of titanium. In this manner I made ferro-titanium practically free from carbon, containing only from 0·18 to 0·50% carbon, and by reducing the amount of scrap iron added I was able to make ferro-titanium as high as 80 to 85% titanium. This aluminium-bath process is of more general application. Thus, if a tungstic ore containing oxide of iron is charged, a ferro-tungsten is obtained free from carbon. I have made thus 85% tungsten alloy. By using manganiferous ores I was able to make in the electric furnace 85 to 88% ferro-manganese free from carbon, and by using chromic iron, a ferro-chrome of about 80% chromium free from carbon.

"By adding to a bath of steel or to cast iron a ferro-carbon-titanium containing 15% of titanium, the bath of metal was cleansed from dissolved or occluded gases, such as oxygen and nitrogen, and from oxides of iron generally present in steel, specially in bessemer steel. When air is blown through the molten pig iron the titanium of the alloy combines with oxygen as TiO_2, with nitrogen as titanium nitride. The oxide of iron is reduced to iron by the titanium and the carbon of the alloy, the titanium combining with its oxygen to form TiO_2. The slag, always present in the metallic bath, rises and carries with it the titanic oxide and the titanium nitride to the top of the ingot or ladle. The TiO_2 entering the slag renders it more fluid and fusible.

"The presence of titanium in steel to the extent of 1% or more imparts to the steel certain special properties. For instance the head of a crucible-steel ingot treated with titanium cast in 1909 had five holes drilled in it to obtain specimens for analysis. These holes are as bright now as they were when first drilled, though exposed to the air in my office. This ingot contains 1·10% titanium, and the steel was so hard that it was drilled with difficulty.

"Copper, as is well known, absorbs when melted a large amount of gases, and the bath contains oxide of copper. For the treatment of copper and its alloys, such as bronze, brass, manganese, or aluminium bronze, I have made a copper-titanium containing any amount of titanium, though 10 to 15% appears better adapted as a scavenger of the copper bath. I have also made aluminium-titanium containing 45% titanium for seasoning aluminium bronzes. They are made in the same manner as ferro-carbon-titanium or ferro-titanium in the electric furnace. For copper-titanium, TiO_2 and aluminium are charged in the furnace in a bath of copper. For aluminium-titanium, the TiO_2 is charged directly in the bath of aluminium. The reaction of aluminium on oxides being exothermic, much less current is required for the reduction proper.

"The affinity of titanium for O and N is such that the metal burns at 800° C. or thereabout in an atmosphere of these gases. The affinity is so strong that when large cakes of alloy free from carbon are broken while hot the section exposed to the air colours itself with fine iridescence, presenting all the colours of the rainbow: blue (probably TiO), gold (probably nitride), copper (probably cyanonitride formed by the small amount of carbon still present), and combinations of these.

"I have experimented with ores containing 1·50 to 2% of phosphorus, adding even apatite to the mixture, so as to obtain a pig iron as high in phosphorus as I could. Contrary to what might have been expected, the pig metal containing 0·40% titanium and from 2·50 to 3·50% phosphorus had the strength of fair No. 1 or No. 2 pig iron. This suggested treating phosphoric pig metal, generally weak and close grained, with ferro-titanium, so as to incorporate an amount of titanium in it. The results were very encouraging and were presented by me at the Pittsburgh meeting of the American Institute of Mining Engineers in 1896. I have also experimented with the smelting of titaniferous ores in mixture with manganiferous ores, even in a coke furnace. I was able to introduce some 3 to 3·50% of titanium in cast iron, and by addition of MnO_2 the pig iron contained 2 to 3%. Manganese appears to cause the titanium to pass into the cast iron, as it alloys readily with titanium.

"If a ferro-titanium practically free from carbon, made by my aluminium-bath method, preferably as high in titanium and low in iron as possible, is dissolved in hydrochloric acid, a fine violet solution is obtained, a ferrous titanium chloride. With this violet solution I have been able to bleach cotton, silk, and wool. As is well known, silk and wool cannot be bleached in agents capable of generating free chlorine, which injures and attacks these fabrics. Still I was able to bleach completely some 2,000 yards of such fabrics by digesting them in this diluted violet solution, boiling for a shorter or longer time, according to the intensity of the dye to be bleached or the yellowish tint of the white fabrics. Silk and wool, coloured or yellowish, were thus bleached without injury to the fabrics. The double chloride contained about 40 to 50% $TiCl_3$, titanous chloride, the balance ferrous chloride. During the operation, especially as the temperature reached near the boiling point, TiO_2 precipitated, thus showing clearly that the chlorine must have been set free and must have combined with the ferrous chloride to form ferric chloride, the chlorine generated acting in the nascent state without even coming as free chlorine in solution.

"The fact that TiO_2 was precipitated from one of its compounds by organic matter suggested to me the possibilities of precipitating TiO_2 from others of its compounds by vegetable or animal organic matter. The results were very remarkable. If to a solution of titanic sulphate, $Ti(SO_4)_2$, is added a water extract of organic vegetable or animal substance, and the liquid is gently digested to boiling and boiled for a short time, TiO_2 is precipitated and, when calcined, is obtained as a soft, smooth, flourlike, pure white powder, requiring no mechanical pulverization. This is such a characteristic of the action of these organic substances that a number of them, such as water extracts obtained from dry leaves, green leaves, sawdust, tannin, wood pulp, woodpulp liquor, horse chestnuts, beans, docks, cranberries, radishes, etc., and urea itself, have given the same results. This method finds a direct application in the production of a white titanic pigment, a product which our company is to manufacture on a large scale. Calcined TiO_2 possesses a remarkable property of covering when used as paint material, alone or in mixture with such other pigments as are used in the trade for paints. Its superiority on this score, when prepared with proper oils, over white lead or white zinc is remarkable, and, besides, TiO_2 pigment is not attacked by gases."

ASBESTOS AT BEACONSFIELD, TASMANIA

In the ***Australian Industrial and Mining Standard*** for December 6, Hartwell Conder describes the asbestos-mining industry at Beaconsfield, Tasmania. This township has dwindled sadly since the closing of the Tasmania gold mine three years ago, but asbestos has, partly, come to its rescue.

Following the road across Brandy Creek, and pursuing a bush track to the west for two miles, a building planted in the bush is reached which, in its glaring brightness, recalls the "White Cities." The whiteness is not confined to the building alone, for the trees and ground around it present a bleached appearance. This is the mill of the Durasbestos Co. recently erected, the first plant established in Australia to concentrate asbestos fibre from the rock. One of the main by-products is an impalpable dust which covers everything within its range. Fans and respirators protect the men from ill effects, and for the rest the dust is just a sign of the progress of work. In the past, asbestos has been imported from Canada into Australia, and there manufactured into slabs and sheets as a building material. At Beaconsfield the occurrence of chrysotile asbestos has been known for over thirty years, and several attempts have been made to utilize it in the past. The serpentine belt is about ½ mile wide and 3 miles long. The asbestos does not occur uniformly through it, but at the northern end on the steep slopes of a hill, and on the river flats of Anderson's Creek below, the occurrences are frequent enough to warrant quarrying the rock for its fibre contents. The fibre is seldom long. One-inch fibre is quite exceptional, and one-eighth inch fibre is satisfactory. The serpentine shows no regular belts or faulting. It is crushed and creviced in every direction, and large heads with smooth slickenside surfaces are exposed, which, after giving every prospect of developing into some established system, break off abruptly before another cross-head coming in at any angle or bearing. Some of the serpentine is pale green or yellow in colour, and to some extent translucent. Some carries considerable quantities of iron and is darker in colour and harder. This latter variety is regarded as more favourable to fibre, but no fixed rule applies. The large crevices and cracks do not usually carry chrysotile fibre, but often carry picrolite. Then the fibres are not transverse, but parallel to the crevices; they are much longer, but are brittle and useless for ordinary purposes. The picrolite fibre is frequently replaced by magnetite, which strongly affects the compass. In fact the serpentine belt as a whole is so magnetic that the compass is of no value for survey work. The actual occurrence of the chrysotile veins repeats the characteristics of the crevicing of the serpentine. They occur without system or continuity. A certain mass of the mother rock may be veined throughout with chrysotile; then abruptly the veins cease, only to be renewed again after a varying stretch of barren country rock. Apart from the presence of iron in the serpentine, the only rule that seems to apply is that the fibre does not occur where the rock is much shattered, and not so frequently where the shattering is slight. The intermediate stage in the crushing of the rock, accompanied by increase in iron content, is most favourable to the development of the fibre, but it is just as difficult to trace these changes in the rock as it is to trace the fibre itself, so that these observations are of little practical value.

As is generally supposed, the hydration of magnesium silicate forming serpentine took place subsequently to the first solidification of the magnesian rock, and was accompanied by increase of bulk in the massive rock. This theory fits in well with what is observed here. The expanding bulk would cause the local cracks and cleavages throughout the rock, and the hydrating solution would penetrate the crevices. In the larger crevices the crystallization would be too rapid, and would probably be affected also by the continued movements, so that picrolite would form. In the heart of the rock crystallization would be more complete, and the silky texture of the chrysotile would have opportunity to develop. To some extent this is borne out by what is known locally as "dead" fibre. In place of true fibre a dull green amorphous mineral, probably olivine, sometimes fills the veins. In all other respects this mineral occurs in exactly similar way to the chrysotile, but the one is live fibre and of value, the other dead and useless. Sometimes a vein may be filled transversely half with live and half with dead mineral; sometimes the good fibre gives way along the course of the vein to the useless variety. On the claim itself, the dead fibre does not occur in sufficient frequency to be of serious moment, but on a hillside, about two miles to the south, over a considerable area, the rock is one network of veins, all of this same class of dead fibre. It is quite possible that with greater depth here the class of fibre would change and yield the useful product.

In addition to this dead variety, there is a variety known as "pétrified" fibre. This has only been uncovered in a few places, and it is remarkable for its fine appearance. It occurs where the alteration to serpentine is not complete, and large dark crystals of bronzite show in the surrounding rock. The mineral is intensely white, and the veins stand out in striking contrast to the dark country rock. Scapolite occurs as a vein about a foot wide in an old quarry on the property, and it is possible that the excess of calcium in the bronzite has here caused the development of this mineral in the veins in place of the purer magnesian silicate of the chrysotile.

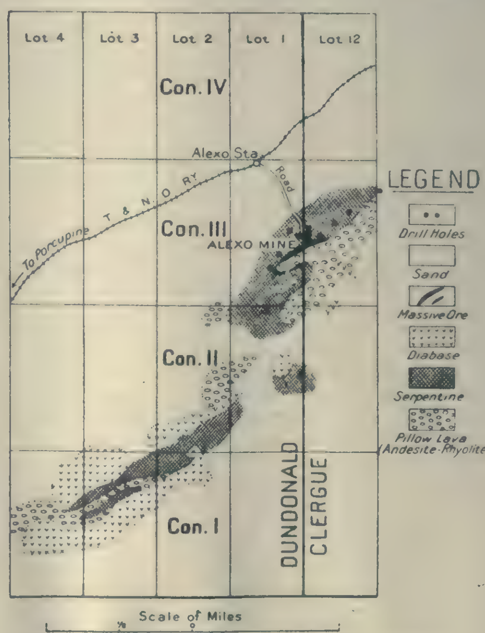
In opening up the property, workings were started high up the hillside, and also near the river flats, where the ground is only about 30 ft. above water-level. It was hoped that the higher quarries would develop best, since the conditions of working and delivery of rock would be in every way better there; but the hill quarry has proved disappointing, and the lower quarry opened up better than anticipated. So much so that the question has arisen whether the fibre favours the softer rock, more prone to decay, and that the river flats themselves may yet prove the most fruitful source. Quarrying has been conducted to a considerable extent, and two benches have been pushed forward, and about 4,000 tons have been extracted. A large proportion of this is waste rock, and was thrown aside at once. The balance was treated in the mill. The mill is on the hillside in a central position. A horse tram about ⅓ mile long, with 1 in 20 grade, conveys the rock to it from the lower quarry. The trucks run back by gravity, and the horse comes back alone by a short cut of steeper grade. A light horse can take up about 1¾ tons per trip in two trucks, while a heavy draught-horse could easily take 2 tons.

The system of crushing is simple. The rock is passed through rock-breaker and rolls till about the size of kidney beans. It is then fed to a disintegrator, with revolving disc and beaters. This machine breaks up the brittle portion of the rock to fine sand, but fluffs up the asbestos till it has the appearance of crude cotton. The product is delivered to a shaking screen, through which the sand passes, while the fluff goes down to the lower end. A narrow spout connected to a suction fan extends right across the screen at the lower end with its mouth close down to it. The fluff is at once caught by the suction, and is delivered to a settling chamber. There are two chambers, and as one is filling, the fibre is being bagged up for shipment in the other. The most troublesome feature is the dust. Fortunately the dust is not of a cutting nature, so that neither to the men or the machinery does it carry the danger that quartz of other gritty dust does. At present, satisfactory results are being obtained, and if the grade of material can be maintained, the success of the enterprise is undoubted. The paper is accompanied by several photographs of the mineral.

THE ALEXO NICKEL MINE, ONTARIO

The 26th Annual Report of the Ontario Bureau of Mines contains a report by Professor M. B. Baker, of Queen's University, Kingston, on the nickel deposit at the Alexo mine, which is situated in the district of Timiskaming, 150 miles due north of Sudbury, and 25 miles north-east of Porcupine. It is well known that nickeliferous deposits are not confined to Sudbury itself but that at various places north of Sudbury masses of serpentine have been found, many of them showing the presence of pyrrhotite, which is frequently nickeliferous. These deposits are in the clay belt of Northern Ontario, which is a great level or slightly undulating plain, with few rock outcrops. These outcrops have proved interesting economically, and indicate a rich and important series of rocks, could they be seen. Mr. Alex. Kelso, the discoverer of the Alexo deposit, was an early settler in this region. In reading the report of the surveyor who ran the township base lines of this district, he noted the reference to great magnetic disturbances, rendering the needle useless at this point on the north and south line. He therefore decided to prospect the district, and in 1908 he found at the foot of a rocky hill much gossan, containing greenish-white nickel bloom, otherwise moresonite. A drilling option was granted to the Canadian Copper Company, but after an apparently unsatisfactory investigation the option was dropped. Mr. Kelso and his friends, however, were not discouraged, and decided to open up the property themselves. E. F. Pullen (now Major, overseas) undertook the management, and in 1912 shipped 1,350 tons of ore to the Mond Nickel Company's smelter. The property has continued to ship since that time, and by the end of December, 1915, had developed 60,000 tons of ore above the 120 ft. level. During 1916, the company did no further development work, but it is the intention to sink further, and open other levels, as soon as power can be spared for the purpose.

The rocks in the district are of four ages, in descending sequence as follows: Pleistocene (clays and gravel); Pre-Cambrian, consisting of (1) Keweenawan (quartz-diabase and olivine diabase), (2) Pre-Algoman



Geological Map of the Alexo Nickel Mine.

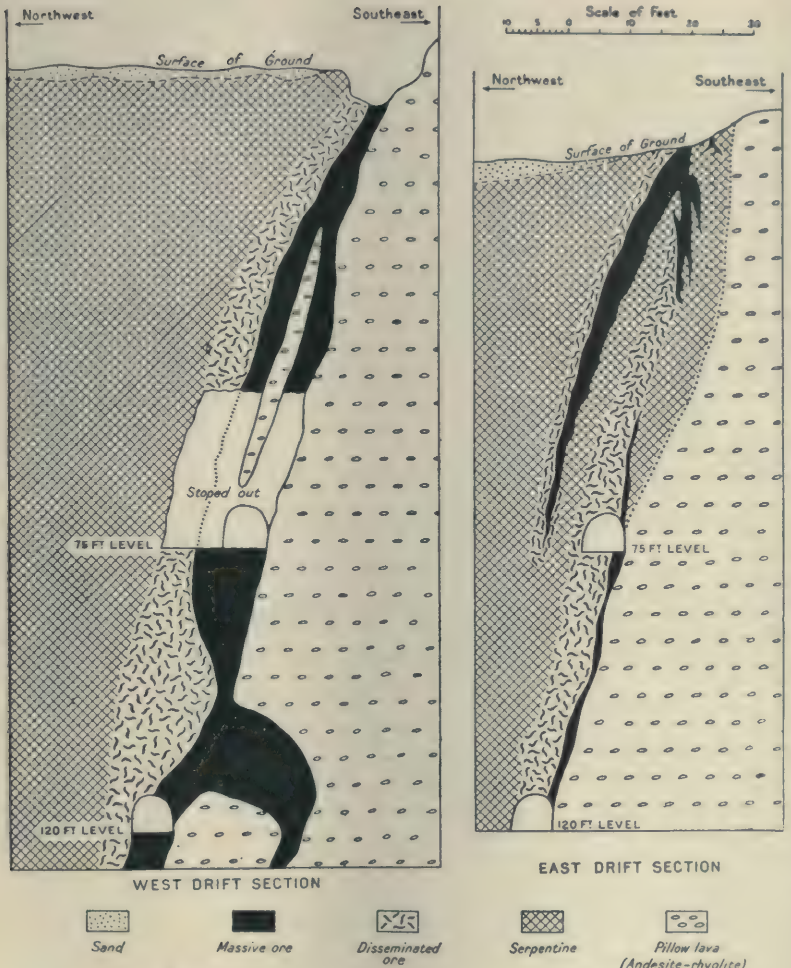


Fig. 2. Fig. 3.

SECTIONS ACROSS EAST AND WEST DRIFTS, ALEXO MINE.

(peridotites now altered to serpentine), (3) Keewatin (pillow-lava, andesite), with abundant ellipsoidal structure; with intrusive contacts between (1) and (2), and (2) and (3). The Keewatin, the oldest rocks, form a series of compact, hard pillow-lavas of dense texture, and of greenish-grey colour when freshly broken. They have been alternatively called rhyolite and andesite by the geologists. They are so much harder than any other rock of the district that they always stand up as a prominent feature of the landscape, and form the high hill at the Alexo mine, at the north-western base of which the ore occurs.

The great Algoman granitic intrusive period appears to have been opened or immediately preceded by a more basic phase of intrusion in most parts of Ontario. In many places these pre-Algoman intrusives are lamprophyric dykes, but in many other cases they are substantial boss-like masses of gabbro, pyroxenite, or peridotite. A large percentage of them consist of this last rock, so that many areas of serpentine are now reported from the northern part of Ontario, which are the result of alteration of original peridotite masses. At the Alexo mine a large mass of peridotite is in contact with the pillow-lava on its north-western flank. The softer peridotite forms the low, flat, more or less swampy ground about the andesite hills. This is an important point for prospectors of this rock. It is almost invariably the lowest ground to be found in the areas in which it occurs. The peridotite at Alexo is now highly altered, and consists largely of serpentine, together with smaller amounts of diallage magnetite, chromite, and calcite or dolomite. Veinlets of asbestos, a small fraction of an inch long, intersect the rock in many places.

Dykes and intrusive masses of the typical Keweenawan diabase are to be found cutting the andesite at the Alexo mine, and also the serpentine a mile south-west. The Keweenawan is a very widespread formation in Northern Ontario, and is made up for the most part of diabases, traps, and gabbro intrusives. These cut the Algoman as well as all earlier rocks.

The ore-body at the Alexo mine lies at the contact of the pre-Algoman peridotite with the earlier Keewatin pillow-lava. It is associated, genetically, with the peridotite or serpentine, and not with the pillow-lava. The ore is of two distinct types. The first is disseminated throughout the serpentine rock which preserves it original texture in every respect (see Fig. 3); the second consists of solid or massive sulphides which occupy spaces or cracks along the actual contact and even fine veinlets and fractures in either wall. The contact of the two rocks strikes north-east and south-west, and has a dip of 65 to 80° to the north-west. The deposit has a proved length of about 700 ft., and has been opened up to depth of 120 ft. Diamond-drilling has proved ore at a depth of 240 ft. The width of the ore-body, counting both the massive and disseminated ore, is quite variable. On the 120 ft. level, for instance, it is 40 ft. wide, while at places in the first level it is not over 3 ft. wide (see Fig. 2). Development work thus far done shows it to average 8 to 10 ft. This offers a satisfactory working width for driving, sinking, or even stoping, as it requires but little timbering. The massive ore consists for the most part of pyrrhotite and pentlandite, with traces of chalcopyrite and pyrite. The nickel-bearing sulphide, pentlandite, occurs in fine veinlets through the pyrrhotite, but can only rarely be seen with the naked eye. Polished and etched pieces of the ore show the pentlandite finely scattered through it in filaments. Chalcopyrite is not at all abundant, and occupies small fractures through the ore, as if introduced later than the pyrrhotite, or else leached from the ore-body into small fractures which developed in it. Pyrite is more abundant, and often forms a substantial proportion of massive ore. Pyrrhotite is much the most abundant sulphide present, and forms a massive deposit resting directly on the andesite foot-wall, in perfectly sharp contact. When broken down in mining, it leaves a sharp and smooth wall. Small veinlets extend into fissures in the andesite, but are just as clearly separable from their walls as is the main vein. The hanging wall of the massive ore consists of disseminated ore, wherever the original vein structure has not been disturbed by faulting. The normal structure clearly shows the foot-wall of andesite, often vertical, or even reversed so as to become for the moment a hanging wall, against which, irrespective of its dip, lies massive ore in sharp, clean-cut contact. This massive ore varies from a few inches up to 20 ft. in width. It is followed by disseminated ore from 3 to 20 ft. wide. The contact between massive and disseminated ore is quite as sharp and clean-cut as is that between massive ore and andesite, and stringers or off-shoots of massive ore penetrate the disseminated ore, all of which shows clearly that the introduction of the massive sulphides was undoubtedly later than the formation of the disseminated ore. The disseminated ore is scattered throughout the rock, forming part of its texture and structure. It grades off into barren serpentine, and is mined as far as it proves economical to do so, the limit of mining depending on variable conditions.

The massive ore carries 6 to 8% of nickel; while the disseminated ore carries about 3%. They are mined and shipped together in the ratio of about 40% of massive to 60% of disseminated ore. Carloads of this mixed ore run about 4½% of nickel. The copper content is less than 1%. An interesting feature of the ore from the smelter's point of view is the magnesium content of the serpentine gangue, for it provides the flux required. The Mond Nickel Company therefore finds the ore to be a useful addition to its smelting mixture as it obviates the necessity for adding lime as flux, as the Canadian Copper Company has to do.

GEOLOGY OF THE SUAN MINING CONCESSION

The Suan Mining Concession in Korea is worked by the Seoul Mining Company, an American organization of which Mr. H. Collbran is president. We have from time to time given records of the work done at the gold-copper-bismuth mines belonging to this company. A few years ago Dr. Malcolm Maclaren made a mineral survey of the Concession and gave valuable advice as to development. An article by D. F. Higgins on the geology and ore deposits of the "Collbran Contact," that is, the contact between an intruding granite boss and the sedimentary beds, along the line of which ore is found, is published in *Economic Geology* for January. As mentioned above, the geological features of the district are, briefly, a series of sedimentary rocks intruded by a granite batholith. The Collbran contact concerned (Fig. 1) is irregularly elliptical in outline with a periphery of about 21 miles. The granite lifted and pushed aside the overlying and surrounding rocks. Erosion has exposed the mass, showing a rim of the upturned edges of the sedimentary rocks around the granite. In the immediate vicinity of the granite the sediments have been metamorphosed more or less profoundly into hornfels, schist, marble, and other metamorphic types. In some of these metamorphosed rocks ore deposits containing copper, bismuth, and gold have been found. The granite core forms the highest part of the Concession, and hence the drainage is roughly radial from the centre of the boss. Streams crossing the contact between the granite and the sedimentary rocks, where gold is present at the contact, carry the metal downstream, across the upturned edges of the sedimentary rocks, which form excellent natural riffles. The Koreans have worked these placers for centuries.

There are at least two sedimentary series on the Concession. The gneiss of the western part may also be of sedimentary origin. This gneiss is the oldest rock in the district. Over it and complexly folded in it are schists and a thin quartzite. The latter rocks are the oldest sedimentaries, if the gneiss should be of igneous origin. The second series is composed of limestones, slates, and quartzites. The intricacy of the structure in the immediate neighbourhood of the contact is such that no definite sequence can be decided upon except from the general field relations. Fossils are lacking; the batholith cuts across the sediments irregularly, and the Hol Kol limestone invariably underlies the Suan slates. In general the field relations show the Hol Kol limestone to be closer to the batholith than the Suan slates. Assuming that the oldest sediments are the nearest to the intrusion, all being upturned about its edges, the following is the order from oldest to youngest: Hol Kol limestones, Suan slates, quartzite (with a little conglomerate), Tul Mi Chung limestone, and Tong Am limestone. The Suan mine and the Tul Mi Chung mine are in the Hol Kol limestone. This is the only limestone surficially in contact with the granite. The Hol Kol limestone is in part pure calcite, in part magnesian, and in no place is it very silicious or argillaceous, though "blue limestone" is abundant. Near the contact, the limestone is usually a marble, characteristically saccharoidal.

In order of age the igneous rocks are as follows. The dolerite from its metamorphosed appearance in the field and under the microscope is considered to be older than the main granite intrusion; originally it was a gabbro composed almost entirely of augite, plagioclase, at least as calcic as oligoclase, and ilmenite. Almost all of the augite has been altered to hornblende (uralite), and the plagioclase to chlorite, quartz, and other alteration products. The ilmenite has been partly altered to leucoxene. Near the western part of the contact are certain dykes and stocks. The Tong Am quartz-diorite dykes, closely related to the "Weigall granite" referred to later, are doubtless one of the last phases of the intrusion of the Suan granite. These dykes have exercised the strongest metamorphic influences observed on the Concession. They carried large amounts of mineralizers and metallic sulphides, including molybdenite in considerable amount. Certain other granites and diorites of this western part seem to be older than the Suan granite, which is the main instrusive.

The "Weigall granite" (so named after Mr. A. R. Weigall, who first identified the rock as being closely associated with the ores in the lower level of the No. 2 cross-cut tunnel at Tul Mi Chung), occurs in large and small dykes in the workings of the Tul Mi Chung mine (see Fig. 4). There it is without doubt closely connected with the origin of the ores. Microscopic study shows the rock to vary from a quartz-monzonite through a quartz-diorite to a mica-diorite. The average composition is probably that of a quartz-biotite diorite. It is probably an offshoot of the parent magma of the

Suan granite intruded shortly after the main mass, but before any great cooling had taken place. The evidence available indicates that the alternation of this igneous rock has been caused by the circulation of hot water through fissures, and presumably given off by the main Suan granite, or possibly, in part, by the "Weigall granite" itself during cooling. These waters were of prime importance in the deposition of the Tul Mi Chung ores. In fact, it seems not improbable that a part of the ore has been deposited in a highly altered phase of the diorite.

The Hol Kol granite and the Tul Mi Chung quartz-porphyry and tourmaline granite are stocks which were in the formation of the ore deposits of the Concession is somewhat problematical. There is little secondary concentration at the Suan mine. In the western ore-body a small amount of secondary chalcocite was observed. The second period of deposition of chalcopyrite may be due to the action of surface waters. On the other hand, at the Tul Mi Chung mine, secondary concentration is evident. The lack of secondary concentration at Hol Kol is no doubt largely due to the rapid run-off caused by the steepness of the slopes. Surface leaching penetrated several fathoms, but even stains of malachite do not occur at depths of over 100 ft. in the eastern ore-bodies. Chalcocite films were seen at depths

FIG. 1. THE SUAN GRANITE AND THE COLLBRAN CONTACT.

intruded soon after the main granite. Tourmaline indicates the presence of mineralizers. They are in all probability differentiation products of the parent magma, occurring significantly close to ore deposits.

The metamorphic rocks are the granite gneiss of the Siroo Pong San boss with its associated schists and quartzite, all products of regional metamorphism; the hornfels, schist, and marble, and garnet-epidote-actinolite, and similar complicated mineral aggregates, in many places highly metalliferous, were formed by the contact metamorphism of the Suan granite. Contact metamorphism has profoundly altered some of the rocks bordering the granite. During an early stage of the metamorphism silicates were developed, and at a later stage the sulphides and metallic gold-silver alloy were deposited. The part which weathering has played of about 200 ft. in the western ore, where topographic and structural conditions are more favourable for the retention of rain-water.

At the Suan mine there are two distinct types of ore in two distinct groups of ore-bodies, known as the western and the eastern groups respectively. The western group includes the locally known "western ore-body"; and the eastern group the locally known "central ore-body" and the "eastern ore-body" with its "north split" and "south split." The ore-bodies of the western group are tabular or lenticular in form and occur on the great fault zone which extends along the west side of the Hol Kol valley (Fig. 2). The ore-bodies of the western group are far more irregular, and occur in a series of interlocking fault zones which make up one large zone about parallel to the contact and ap-

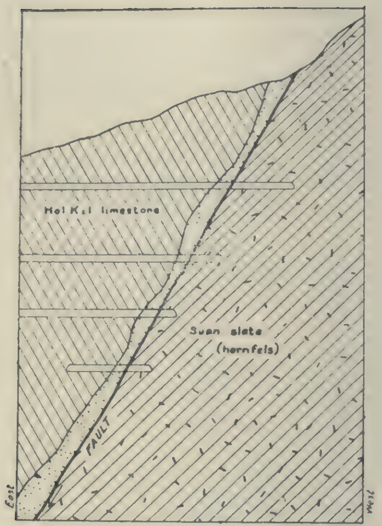


FIG. 2. WESTERN GROUP OF ORE-BODIES, SUAN MINE.

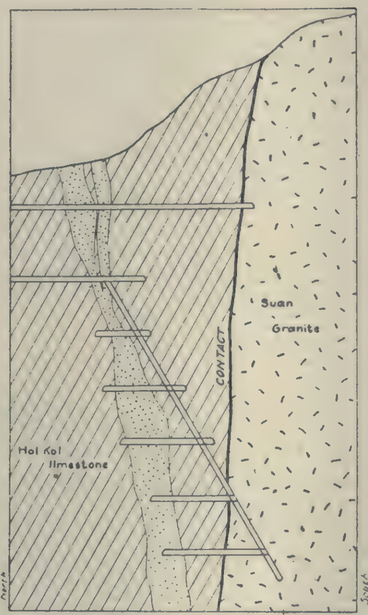


FIG. 3. EASTERN GROUP OF ORE-BODIES, SUAN MINE.

proximately at right angles to the west fault (Fig. 3). In this zone the last movement was downward about 30° toward the south, and was probably caused by a settling of the granite in cooling. As a whole the zone dips 60°–80° toward the contact in the upper levels, but is about vertical in the lower levels of the mine. The western zone dips 50°–60° to the south, and extends into the granite ; while the eastern one runs about parallel to the contact. Distinctive minerals of the western group are tetrahedrite and dolomite, which occur with the other ore and gangue minerals. Sphalerite and galena may also belong to this category, as they were not certainly recognized in the eastern group. Tetrahedrite and dolomite are never found in the eastern group.

It is clear from both structural and mineralogical evidences that the ores of the two groups have originated differently from the same magma. The ore of the western group was deposited from solutions carrying gold, silver, copper, iron, zinc, lead antimony, bismuth, and magnesium, working up and laterally along the fault zone from the granite into the limestone. The deposits are in the limestone hanging-wall, none having been found in the hornfels foot-wall. Certain silicates had been developed prior to the deposition of the sulphides. The ore replaced the calcite in preference to these silicates, and filled fractures. Minute veinlets of chalcopyrite constitute the last stage of the mineralization. In the eastern group, solutions carrying gold, silver, copper, iron, and bismuth, emanating from the granite, passed upward along the complicated channels of the fault zone. The author proceeds to discuss the origin of the ore-bodies.

Sodium Manganate.—The *Journal* of the Chemical, Metallurgical, and Mining Society of South Africa for January contains a short paper by F. Wartenweiler describing a method of making sodium manganate suitable for use in place of permanganate of potash, which is too expensive and scarce nowadays, wherever that oxidizing agent has been required in the mine or the metallurgical plant. By this method the oxidizer can be easily made on the spot. Mr. Wartenweiler's experiments were conducted in a four-hearth brick muffle-type furnace, ordinarily use for calcining acid-treated zinc-gold precipitate. The materials used are pyrolusite containing 40% Mn, and caustic soda. The reaction may be expedited by the addition of potassium nitrate, but this also is expensive nowadays.

The mixture found most effective was : 1 part by weight of 40% Mn ore to 1·44 parts of caustic soda. Results were obtained in two hours by heating at a temperature ranging from 650° to 750° C. The product has analysed 18·2% sodium manganate on an average. With only one hour of the same heat, an average of 17·2% was produced. By heating at a lower temperature and over a longer period a richer product (28%) was made. The method in this case was to heat the furnace to a temperature of 450° C. prior to adding the charge, add the charge, and gradually raise the heat to about 560° C., maintaining this heat for eight hours, then allowing the furnace to cool for four hours, when the charge may be withdrawn. This method was finally adopted. The laboratory tests were carried out with ore ground to 86·6% of minus 90 mesh, with practically no plus 60 mesh. No improvement in conversion resulted from the use of the more finely comminuted ore. The chemicals are well mixed before feeding to the furnace in charges up to 500 lb. for each one of the four hearths. This amount forms a mass over the hearth about 6 in. deep. No stirring or rabbling is necessary. By the end of the heat, the product has agglomerated, and has to be prised out of the furnace in a more or less lumpy condition, which necessitates breaking before dissolving. The lumps retain their manganate strength longer than the finely crushed product when left exposed to the air. As the sodium manganate decomposes gradually upon exposure to air, it is packed in sealed packages and should be so stored. The loss of weight during the reaction in the furnace has been found to average 12·5% ; that is, for every 100 lb. for charge used, 87·5 lb. of crude sodium manganate is produced. A large amount of uncombined caustic soda is present in the crude manganate product, as is shown by its causticity. No attempts have been made to produce a refined product, as the crude manganate can be used on the mines for all purposes for which formerly the refined potassium permanganate was used. The manganate is more soluble than bleaching powder, and is easier to handle and control. When once dissolved and converted to permanganate by dilution with water it is comparatively stable.

Economizing in Mercury.—In the January *Journal* of the Chemical, Metallurgical, and Mining Society of South Africa, Dr. W. A. Caldecott writes of the present position of the Transvaal gold mines as regards mercury supply for amalgamation purposes, and the possibilities of economizing or even of substitution. The local price is now £27 per flask of 75 lb., as compared with £8 before the war. The mercury as used at the gold mines is in continual circulation and re-use on the plates, as amalgam, and in the retorts, with a constant wastage.

The chief wastage is due to minute particles being abraded from the amalgamating plates by the particles of ore in the pulp passing over them, and which naturally increases with the coarseness and velocity of the pulp. On one group of mines without stamp-mill plates, the total consumption of mercury (in Troy ounces) per ton of ore milled is on an average equal to 7% of the amalgamated plate area (in square feet) in use per ton of ore milled in 24 working hours. In consequence of fluctuations in the amount of mercury retained on plates and in tube-mills, launders, pump pits, etc., it is necessary to take periods of several months to obtain correct comparative figures regarding average actual consumptions of mercury.

Very finely divided or floured mercury in the pulp leaving the crushing plant is deposited in the collected sand and slime, and subsequently largely dissolved by the cyanide solution along with the gold, and, under certain conditions, similarly precipitated in the zinc-boxes. Possibly a portion of the mercury after dissolution is precipitated in the charge, like a dissolved lead salt, as sulphide, by soluble sulphides derived from the ore, and hence finally discharged with the sand and slime residues. Any loss of mercury from this source might possibly be decreased by increased use of lead salt in the working solutions.

A little mercury is lost mechanically in handling as amalgam, or during steaming and retorting as vapour. Some goes into the black-sand by-product. This black-sand by-product is sold to the Witwatersrand Co-operative Smelter and the mercury is recovered. The actual consumption of mercury in a reduction works naturally increases with an increased area of amalgamated plates in use.

In a modern plant, without plates in the stamp-mill, practically all the gold recovered by amalgamation on the tube-mill plates has previously been classified out of the pulp with the coarser particles by the tube-mill and safety cones, and hence efficient classification is the primary requisite for ensuring a satisfactory amalgamation recovery of the gold contents of the ore, and for reducing to a minimum the loss of mercury in the tube-mill return pulp. Practice regarding the tube-mill plate area considered necessary varies considerably on different mines, from three 4 ft. 9 in. by 12 ft. plates per tube-mill to six plates and upward per tube-mill. The capital represented by the plates, copper, and amalgam, and the labour of dressing, increase with the number of plates. In consequence of different practice, the mercury consumption per ton of ore milled varies greatly from an average of 0·04 oz. per ton of ore milled on certain mines to an average of about 0·12 oz. per ton of ore on the majority of Rand mining companies.

In view of the present pooling system for mine supplies, all mines have a common interest in the saving of mercury. Although blankets could be employed in place of plates if absolutely necessary, yet this course would involve additional labour and expense, to be avoided if possible.

It may prove practicable to pass the gases from the calcination of zinc-gold slime for the recovery of mercury through condensing flues and chambers or filters. One form of condenser consists of the flue-pipe led through a tank of water to cool it. A good many years ago Dr. Caldecott recovered a flask and a half of mercury by retorting the acid-treated zinc-gold slime from Sheba pan-tailing.

Tuckabianna, West Australia.—In recent issues we have published brief references to gold-mining at Tuckabianna, but the information so far obtainable has been somewhat obscure. We quote herewith a report in the district, made by T. Blatchford, Assistant Government Geologist, published in the *Chemical Engineering and Mining Review*, of Melbourne, for January.

Tuckabianna is 4 to 5 miles north-east of the Pinnacles, which is 12 miles south-west of Cue. In general, the geological features of Tuckabianna resemble those of the Pinnacles and Webb's Patch. They consist of extensive well-defined bands of quartz hematite schists (locally known as jaspers or ironstone bars) in foliated greenstone, the latter being bounded on both sides by granite. Intruding the greenstones, and possibly the quartz hematite schists, are hornblende quartz-porphyries. Any available specimens of greenstone at Tuckabianna were so highly weathered as to be useless for accurate determination. It is therefore impossible at present to state definitely whether the greenstones there will link up with those of Webb's Patch or the Pinnacles. However, Webb's Patch is on the same strike as Tuckabianna. Porphyritic dykes occur both at Tuckabianna and Webb's Patch, and not at the Pinnacles, so that there is a probability of the former being the case, and that Webb's Patch and Tuckabianna are the same series. Though highly weathered, the porphyrite dykes are distinguishable at Tuckabianna as white or yellowish rocks, through which are scattered numerous grains of original quartz. In several of the mines this form of rock is known as the "white foot-wall rock." It differs only in appearance from much of the weathered greenstone, in that it is not foliated, and is gritty to the touch on account of the quartz grains.

There is a large development of quartz-hematite schist at Tuckabianna. It occurs as parallel bands of varying thickness in the greenstone. Some of the bands have a thickness of at least 60 ft., possibly more. They vary in composition from a silicious ironstone to one almost wholly quartz. The gold occurs in certain portions of the quartz-hematite schists, and not in quartz reefs. There are two geological features closely associated with the occurrence of the gold which are worthy of special notice: (1) The bands in which the gold occurs are much contorted or even brecciated. This is particularly noticeable in the Italians' claim; (2) porphyrite dykes occur as one of the walls of the gold-bearing band as at the Blue Streak, and Cameron & Ward's. These dykes are locally known as the "white foot-wall." It is not evident whether porphyrite dykes occur in the Italians' claim or Faherty's, for up to the present time there has not been any cross-cutting in either of these mines into the foot-wall.

There seems little doubt that the higher grade ore occurs in pipes or shoots with a dip to the north, but as the greater portion of the surface is more or less obscured by an overburden of surface detritus, and as up to date there has been very little driving along the course of any of the lodes, the extent of the payable portions is not determinable. It is evident, however, that highly payable ore has been mined at several points along an extended line, and that there is still ample room for further prospecting. That payable ore will be found only in narrow shoots, though probable, is still problematical, and there is ample ore opened up to encourage further development. Many of the prospectors now in the field seemed anxious to know how the "jasper bars" were running, but at the present time they have no map to guide them.

The following is a list of crushings compiled from official records. As in some cases almost half the gold contents pass into the tailing, the assay-value of the tailing, where known, has been added in a footnote.

	Tons crushed.	Gold Fine Oz.
Blue Streak	70·00	44·73
Gold Streak	13·00	3·31
Nigel	39·00*	182·44
Tosiana	385·00†	849·76
Tuckabianna (North)	32·50	33·54
Triplicate (Syndicate)	439·00	116·71

* Gold in tailings, 126 oz. † Gold in tailings, 877 oz.

The Roasting of Tin Ores.—At a meeting of the Cornish Institute of Engineers held in February there was a general discussion on the subject of roasting tin and wolfram concentrates. As has been pointed out on several occasions, particularly by William Thomas, losses occur during the roasting, losses that have been unsuspected or ignored. Among the members contributing to the discussion may be mentioned M. T. Taylor, H. W. Hutchin, and J. W. Chenhall. We quote Mr. Taylor's remarks herewith, and hope to report the views of other engineers on a later occasion.

Mr. Taylor referred first to experiments made with the object of ascertaining the temperature for obtaining the most complete precipitation of arsenic soot. In these tests the temperature immediately above the fire of the Brunton calciner was found to be 1,340° F. In the centre of the revolving deck the temperature was 1,100° F. Close to the flue, on the outlet side, the temperature recorded was 1,000° F. At a point 20 ft. along the arsenic flue, away from the calciner, the temperature was 600° F., and at 140 ft., the next point at which the test was made, the pyrometer registered 340° F. It is at this point where the first deposition of the arsenic soot took place. At a distance 240 ft. along the flues, 296° F. was registered, and it was at this point that the best deposition was obtained. At 700 ft. a considerable amount of moisture was observed on the outside of the test tube, and the degree registered was 118° F. Most of the arsenic soot was deposited before reaching this point. The next test was made at the bottom of the outlet stack, which is 100 ft. high. The temperature at the base registered 80° F. The gases, from the time they leave the calciner, travel 1,000 ft. through the flues before they are liberated in the atmosphere at the top of the stack. It is notable that up to 140 ft. away from the calciners, where the temperature registered 340° F., very little deposition took place, but from 140 to 240 ft. where the temperature ranged from 340° down to 297° F., more than 90% of the arsenic soot was deposited.

Mr. Taylor proceeded to discuss the amount of decrepitation that takes place in both wolfram and tin ores during calcination. This decrepitation has the effect of comminuting the material, and as the material has subsequently to undergo the second series of concentrations, the increased fineness leads to losses. He presented the tables given in the next column containing the results of laboratory experiments, which indicate the losses due to this action. The ores treated in his experiments were rich mineral practically free from gangue.

Two tests were made on wolfram and four on tin ore. The first temperature was 1,500° F. The original materials for these tests were minus 40 plus 60. It was found that of the wolfram material after calcination 61·1% went through 60 mesh while 18·5% was minus 200. The temperature was then raised to 2,000° F., and the same ore samples were used; the result was that 73% went through 60 mesh while 21% was minus 200. The latter product was extremely fine, resembling graphite, and on a vanning assay very little could be retained. With the tin ore, the original products were the same as the wolfram, namely, minus 40 plus 60, and the samples were obtained direct from the mine, not being previously crushed or treated. The tin ore at 1,500° F. showed that after calcination 21·25% passed through 60 mesh and 2·25% was minus 200, while at a temperature of 2,000° F. 22% passed through 60 mesh and 3·25% was minus 200. In the wolfram treated at 2,000° F. very little sintering was noticeable to the naked eye, but with the tin product an excessive amount of fusing and sintering was in evidence. The above figures prove that calcination should not be carried out at a temperature above 1,500° F., and that the higher the temperature the greater the decrepitation. From the evidence so far obtained it would appear that a temperature between 1,100 and 1,300° F. is a suitable one for calcination.

DECREPITATION OF WOLFRAM ORES AT 1,500° F.

Experiment	Loss in burning	Screen Analysis of Roasted Product.					
		−200	+200	+150	+100	+80	+60
A	3·0	16·0	4·25	9·5	5	27·5	34·75
B	2·0	19·75	4·25	8·5	5	24·5	35·0
C	2·0	19·0	4·25	7·25	5·5	32·0	30·0
D	1·5	19·25	2·0	8·0	4·75	29·5	35·0
Average	2·1	18·5	3·7	8·3	5·2	28·3	33·9

DECREPITATION OF WOLFRAM ORES AT 2,000° F.

	2·5	21	4·5	7·0	5·5	32·5	27

DECREPITATION OF TIN ORES AT 1,500° F.

Experiment	Loss in burning	−200	+200	+150	+100	+80	+60
A	1·5	2·5	0·75	1·75	2·5	13	78
B	1·5	2·25	0·75	2·0	2·5	12·5	80
C	1·5	2·25	0·75	2·0	2·5	12·5	80
D	1·5	2·25	0·75	2·0	2·5	12·5	80
Average	1·5	2·25	0·75	1·75	2·5	12·5	78·75

DECREPITATION OF TIN ORES AT 2,000° F.

	0·5	3·25	0·75	2·0	2·75	12·75	78

SHORT NOTICES

Fireproofing Mine Timber.—The March *Bulletin* of the American Institute of Mining Engineers contains a paper by E. M. Norris describing the methods used by the Anaconda company for fireproofing the timber in mine shafts. This is done by covering with a coat of concrete fired by a cement gun.

Air Blasts.—In a paper appearing in the March *Bulletin* of the American Institute of Mining Engineers, E. S. Moore discusses the air-blasts, or rock bursts, that occur in the Mysore gold mines.

Electric Cables in Mines.—*The Iron & Coal Trades Review* for March 22 prints a paper on the care and testing of electric cables in mines, read by A. F. W. Richards before the National Association of Colliery Managers and the Association of Mining Electrical Engineers.

Top-Slicing.—At the February meeting of the American Institute of Mining Engineers, W. G. Scott presented a paper describing the latest application of the incline top-slicing method at the Coronado mine of the Arizona Copper Company.

Shaft-Sinking. — In the *Colliery Guardian* for March 28, W. H. Maxwell commences a series of articles on modern methods of shaft-sinking.

Flotation.—In the *Mining and Scientific Press* for February 9, W. H. Coghill writes on the flotation of chalcopyrite-pyrrhotite ore.

Prestea Block A.—In the *Engineering and Mining Journal* for February 23, Paul T. Bruhl discusses metallurgical practice at Prestea Block A., West Africa.

Electrolytic Zinc.—The March *Bulletin* of the American Institute of Mining Engineers contains a lengthy paper by C. A. Hansen on investigations conducted at the Bully Hill plant in California into the effect of various impurities on the electro-deposition of zinc.

Aluminium.—*Metallurgical and Chemical Engineering* for February 15 contains a paper by R. J. Anderson on the metallography of aluminium, relating particularly to the preparation and etching of sections for the microscope.

Copper Ore Analysis.—*Metallurgical and Chemical Engineering* for February 15 contains a paper by C. E. Van Barneveld and E. S. Leaver describing experiments on methods of estimating oxidized copper compounds in copper ore where the copper also exists as sulphides.

Copper Ore Assays. — In the *Engineering and Mining Journal* for February 23, C. G. Maier gives a method in use at the Phelps-Dodge laboratories for determining the relative amounts of copper in ore in the sulphide form and as oxidized leachable form respectively.

Manganese in Aluminium.—In the *Engineering and Mining Journal* for March 2, J. E. Clennell gives two new methods for estimating manganese in aluminium alloys and aluminium dust.

Metallurgical Laboratory. — In the *Engineering and Mining Journal* for March 9, B. B. Hood describes the new laboratory of the United States Metal Refining Co., at Chrome, New Jersey.

Geology of Mysore State.—At the meeting of the Geological Society held on March 20, Dr. W. F. Smeeth gave a lecture on the geology of Southern India, with particular reference to the Archean rocks of Mysore State.

Kaolin.—In the *Geological Magazine* for February, J. B. Scrivenor describes veins of pure kaolin found in clay above limestone at Gopeng and elsewhere in the Kinta district, and in quartzite and shales near Tanjong Malim and Kerling, Selangor. He speculates on their origin, and mentions the possibility of establishing a kaolin industry.

Studies in Faulting.—In the *Journal of Geology* for February, R. T. Chamberlin and W. Z. Miller write on overthrust faults at low angles.

Ore Deposits.—In the *Mining and Scientific Press* for January 26, Stephen Taber writes on the effect of the force of crystallization in the formation of ore deposits.

Komspelter.—In the *Mining and Scientific Press* for March 2, T. A. Rickard commences a series of articles on the zinc-lead ore deposits recently developed in Oklahoma, over the border of Kansas and Missouri, and belonging to the same mineral district as the celebrated Joplin mines. Mr. Rickard has overcome the difficulties experienced in finding a comprehensive name for the district, to include old and new deposits, by using the name Komspelter. The first three letters are the first letters of the three states.

Magnesite Bricks.—At the March meeting of the English Ceramic Society, W. Donald read a paper on magnesites and magnesite bricks. The author is a maker of this class of brick.

RECENT PATENTS PUBLISHED.

1,393 of 1916 (103,990). R. B. MARTIN, New York. In flotation processes, the addition of a soluble sulphide to the pulp as frothing agent.

1,394 of 1916 (103,991). R. B. MARTIN, New York. In flotation processes, the use of oil, to which sulphur has been added during heating, as frothing agent.

1,440 of 1917 (112,973). R. T. GLAZEBROOK, W. ROSENHAIN, and E. H. RODD, London. Method of producing pure zirconia.

2,579 of 1917 (113,326). W. J. GEE, London. Improvements in centrifugal machines for separating and grading minerals.

2,819 of 1917 (113,648). S. CROOK and F. W. GILBERTSON, Pontardawe, Glamorgan. A manure made by mixing nitre cake, that is bi-sulphate of soda, with mineral phosphate.

3,285 of 1917 (113,508). C. O. GRIFFITH, Wormit, Fife. An electrolytic process for producing sulphides from ore, antimony sulphide being specially mentioned.

3,721 of 1917 (113,351). A. S. LARSEN, Christiania. Method of producing iron sponge from ore by the action of gases containing hydrogen.

5,463 of 1917 (105,915). L. E. TISSIER, Batna, Algeria. Utilizing the heat of the exhaust of gas engines for calcining or roasting ores.

6,484 of 1917 (113,202). DIVER MINERAL SEPARATOR CO., Calgary. An amalgamator in which the pulp is forced directly into a bath of quicksilver.

8,010 of 1917 (113,211). E. A. ASHCROFT, London. Method of obtaining potassium chloride from felspar. This process was described in the inventor's paper read before the Institution of Mining and Metallurgy last December.

9,053 of 1917 (113,393). L. VAN GLUCK, Swansea. Improvements in gas-fired furnaces used in connection with the distillation of zinc ores.

9,852 of 1917 (108,308). G. GRONDAL, Djursholm, Sweden. In flotation, a method of introducing the gas and oil particles from the bottom of the cells.

10,379 of 1917 (109,435). E. S. BERGLUND, Trollhattan, Sweden Improved methods of leading zinc vapour from electric smelting furnaces to the condensers.

10,554 of 1917 (109,790). M. BARNETT, L. BURGESS, and STANDARD OIL CO., New York. Making anhydrous aluminium chloride by treating aluminium carbide with dry hydrochloric acid, at a temperature above the volatilization of the chloride.

11,522 of 1917 (109,257). METALS DISINTEGRATING CO., and E. J. HALL, New York. Method of producing zinc dust and dust of other metals by means of jets of air or other gases impinging on a stream of molten metal.

15,682 of 1917 (110,758). E. H. MOLL & CO., and A. H. ALEXANDRE, Paris. Soldering composition for aluminium, consisting of tin and zinc, with a small admixture of stearine.

15,982 of 1917 (113,584). H. O. H. WENMAN, Bishop's Castle, Shropshire. Method of making phosphorus by the treatment of basic slag in an electric furnace.

17,036 of 1917 (111,668). RAFFIN ET FILS, Nice. Method of producing titanic oxide from ilmenite ores.

COMPANY REPORTS

British Aluminium.—This company was formed in 1894 to produce aluminium from its ores. It owns bauxite deposits in the north of Ireland and in the south of France. The first smelter was at Foyers in Scotland, and subsequently a larger plant was built at Kinlochleven, near Ben Nevis, 50 miles south-west of Foyers. The electric current used in smelting is generated by water-power. The company is now seeking powers to extend the works at Kinlochleven and to build additional reservoirs. The company also has works in Norway and Switzerland. The report for the year 1917 shows a profit of £347,474, out of which £70,000 is allocated for depreciation, £75,000 is placed to reserve account, and £48,000 and £43,223 respectively are placed to the requirements in connection with prior lien debenture stock. The preference shareholders received £17,974, being at the rate of 6%, and the ordinary shareholders £60,062, being at the rate of 10%. No details of the output or of technical matters are published.

South Crofty.—This company was formed in 1906 by the Allen-Meyerstein group to acquire the tin-wolfram-arsenic mine of this name, near Camborne, Cornwall. Dividends have been paid continuously since 1909. Josiah Paull is manager. The report for the year 1917 shows that 70,055 tons of ore was raised and sent to the mill, and that the yields were as follow: tin concentrate 610 tons selling for £84,438, wolfram 87 tons selling for £14,724, arsenic 828 tons selling for £40,388, the total receipts being £139,981, or 39s. 11d. per ton. The yields the year before were 607 tons, 95 tons, and 783 tons, and the revenues £63,708, £14,772, £24,391, and £102,872 respectively. It will be seen that the receipts for tin and arsenic are substantially higher, owing to the increased prices obtained. The profit for the year was £41,530, as compared with £16,703. Out of the profit, £35,000 has been distributed as dividend, being at the rate of 17½%. Mr. Paull refers to the exploration for the Rogers lode; we mention this matter in our Review of Mining.

East Pool & Agar. — This company was originally formed in 1834 to work tin mines between Redruth and Camborne, Cornwall. After 1905, the grade of the ore fell, and profits and funds for development became scanty. In 1913 the position was saved by the introduction of new capital and by placing the management in the hands of Bewick, Moreing & Co. At the same time the company was reconstituted under limited liability law. We have already recorded how the explorations recommended by Dr. Malcolm Maclaren revealed the existence of a bonanza, now famous as the Rogers lode. We have also mentioned that acting under the urgent demands of the Munitions Department for more tin, the company is to draw more rich ore from the Rogers lode and so double the output during 1918. The report for the year 1917, just issued, shows that 77,287 tons of ore was raised and treated, for a yield of 943 tons of tin concentrate, 71 tons of wolfram concentrate, 5 tons of copper concentrate, and 488 tons of arsenic. The average recovery of the tin content of the ore was 72%. The receipts from the four products were respectively: £129,263, £12,875, £60, and £34,062, making a total of £176,260. The net profit for the year was £59,651, out of which £24,060 has been paid as dividend, being at the rate of 25%. A large balance is being carried forward in order to provide funds for the increased development and plant involved in the arrangement with the Government mentioned above. Of this amount £20,000 is now being capitalized, by the issue of 20,000 new shares. A large amount of high-grade ore in the Rogers lode was added to the reserves during the year. M. T. Taylor is manager at the mine.

Cordoba Copper.—This company was formed in 1908 by John Taylor & Sons as a consolidation of the Cerro Muriano and North Cerro Muriano companies, operating copper mines 10 miles north-east of Cordoba, South Spain. Dividends were paid for the years 1912, 1913, and 1916. Latterly the grade of the ore developed has substantially fallen. The report for the year 1917 shows that 76,146 tons of ore averaging 2·23% copper was raised, and after the rejection of waste, 61,373 tons averaging 2·77% was sent to the concentrators. At the smelter, 1,304 tons of blister copper was produced. In addition 1,484 tons of custom ore was purchased, the yield from which was 250 tons of blister, bringing the total output to 1,554 tons. The sale of the copper gave an income of £189,481, and other items brought the revenue to £193,614. The working cost was £155,533, and £24,567 was spent in the purchase of ore. The profit for the year was £13,513, out of which £9,000 has been written off for depreciation of plant, and the rest carried forward. The heavy rainfall of 1916 and the early months of 1917 flooded the lower workings. The pumping plant was not powerful enough to remove the water promptly, and it was not at work all the time owing to interruptions in the delivery of coal. Some time ago it had been decided to provide a new electric pumping plant, but delays have intervened and the plant was not available for draining the mine. With regard to future policy, Ernest R. Woakes has recently visited the mine to confer with James Hocking, the superintendent. It is advised to abandon the workings on the main Cerro Muriano lode owing to continued failure to find further supplies of ore, and to undertake a vigorous policy of development in the northern sections of the property, particularly on the Calavera, Lorenzo, and Excelsior lodes. A promising discovery was recently made in the 850 ft. level west of the Lorenzo shaft.

Messina (Transvaal) Development.—This company was formed in 1905 by A. M. Grenfell to acquire a copper property in the northern Transvaal. Three years ago, on Mr. Grenfell's retirement, H. C. Hoover became chairman and appointed a new manager. Mr. Hoover resigned the position a year or more since, on his return to America, and C. F. H. Leslie is now chairman. The policy has been to ship the rich ore, concentrate, and matte to this country or elsewhere. Owing to the high cost of freight to the coast, no profits were made for over ten years. More recently, with railway communication and the higher price of copper, dividends have become possible, the first payment being made in 1916. The report for the year ended June 30, 1917, shows that 140,232 tons of ore was raised from the Messina mine, assaying 3·87% copper. This figure for the content compares with 5·44% for the previous year, and 7·33% for the year ended June 30, 1915. The shipping concentrate produced amounted to 8,343 tons averaging 47¾% copper, and the concentrate for local smelting amounted to 5,686 tons averaging 20¾% copper. At the smelter 1,849 tons of matte, averaging 62% copper, was produced. The accounts show an income of £653,105 from the sale of concentrate and matte, and a gross profit of £278,161. Out of this, £40,000 has been placed to the reserve for local taxes, £15,000 has been paid as debenture interest, £35,000 has been allocated to debenture redemption, and £36,357 was paid on May 14, 1917, as dividend, being at the rate of 5%. The balance of £156,687 is carried forward, awaiting decision as to liability for excess profits duty. The ore reserve is estimated at 268,447 tons averaging 3·52%, as compared with 208,061 tons averaging 4·74% the year before. The content of the ore now being developed is much lower than formerly. As recorded in our last issue, shipping facilities for the concentrate and matte have been withdrawn.

Wolhuter Gold Mines.—This company was formed in 1887 to acquire claims on the outcrop in the central Rand, to the east of the Meyer & Charlton. During the early years the results were poor, and dividends have only been paid for the years 1894, 1897, 1898, and from 1909 to date. The report for the year ended October 31 last shows that 462,588 tons of ore was raised, and after the rejection of 12% as waste, 406,650 tons averaging 6·26 dwt. was sent to the mill. The yield of gold was worth £500,455, or 24s. 7d. per ton milled, and the working cost was £361,113, or 17s. 9d. per ton, leaving a working profit of £139,342, or 6s. 10d. per ton. The shareholders received £96,750, the dividend being at the rate of 11¼%. The ore reserve is estimated at 1,071,640 tons averaging 5·6 dwt., a fall of 230,520 tons and 0·4 dwt. as compared with the figures of a year ago. Little ground remains to be developed, all of this being in the south-east corner of the property. During the year the control has passed from the Neumanns to the Rand Mines group, by the deal made after the death of Sir S. Neumann.

Tweefontein Colliery.—This company was formed in 1907 by Henderson's Transvaal Estates to work the colliery on Tweefontein farm in the Middelburg district of the Transvaal. The report for 1917 shows that the prosperity of the enterprise continues. The sale of coal amounted to 444,115 tons, as compared with 436,898 tons in 1916. The net profit was £26,431, out of which £7,500 has been paid on the participating preference shares, being 10%, and £15,000 on the ordinary shares, being 25%.

Associated Northern Blocks.—This company was formed in 1899 to acquire the Iron Duke leases at Kalgoorlie, West Australia, and satisfactory dividends were paid for some years. Six years ago, on the approaching exhaustion of the mine, the Victorious property at Ora Banda, 35 miles to the north, was bought. At the end of 1915, the Gimlet leases at Ora Banda were acquired. The report for the year ended September 30 last shows that, at the Iron Duke, tributers raised 6,025 tons of ore, which yielded gold worth £12,965, of which £2,581 accrued to the company as royalty. In addition 281 tons of old residue was treated, yielding £1,548, of which £429 accrued as royalty. At the Victorious mill, 6,198 tons of ore from the Victorious mine, and 18,922 tons from the Gimlet mine, were treated, yielding gold worth £51,644. At the Victorious mine, operations were confined to extracting any remaining ore on the No. 6 level. At the Gimlet, the shaft has been sunk, and a third level opened. The results here obtained are found to be sufficiently encouraging to warrant sinking another 100 ft. No estimate can be made of the reserve, but there is plenty of ore to keep the mill going. The accounts show a profit of £9,961, against which £8,354 has been written off for depreciation and for development and shaft-sinking expenditure during the year. No dividend has been paid since 1913.

Mysore Gold.—This company was formed in 1880 by John Taylor & Sons to acquire old workings in the Kolar district of Mysore, South India. Dividends were first paid in 1886, and from then onward the output and rate of profit steadily increased, until, in 1915, the results of developments ceased to keep pace with the output and the average grade of the ore treated became lower. The report for the year 1917 shows that 307,126 tons of ore was treated for a yield by amalgamation of 160,627 oz. of gold bullion, being 10·4 dwt. per ton; in addition 261,299 tons of sand tailing was treated by cyanide for a yield of 29,705 oz. of gold bullion, being 2 dwt. per ton, and 262,156 tons of slime was treated for a yield of 29,985 oz. of gold bullion, being 2·3 dwt. per ton. The sand tailing and slime were partly current products and partly accumulations. The total gold bullion was 217,317 oz., equivalent to 198,446 oz. fine, and realized £842,056. The net profit was £404,296, out of which £100,137 was allocated to capital expenditure, and £259,250 was distributed as dividend, being at the rate of 85%, less income tax. The figures for the yield of gold bullion by amalgamation and cyanide respectively, 160,627 oz. and 59,695 oz., compared with 164,145 oz. and 52,374 oz. the year before, and thé yield per ton by amalgamation, 10·4 dwt., compared with 10·7 dwt. Owing to more tailing being treated, the total gold yield was fully maintained. The cost of operations naturally increased, owing to war conditions, and the dividend rate of 85% compared with 95% in 1916. The first part of the tube-mill installation for regrinding current tailing and for re-treating old dumps of sand tailing came into operation in June, 1917, and the remainder in October. The re-treatment of the old dumps will help to swell the total yield and so will counteract to some extent the continued fall in the yield from the current ore. On the other hand the old accumulations of slime are nearly exhausted. R. H. P. Bullen, the superintendent, reports that developments in Ribblesdale's section, the deepest workings on the property, are becoming more hopeful, after having passed through much unprofitable ground, for in a winze below the 53rd level south the lode has averaged 15·6 dwt. over 2 ft. for a depth of 42 ft. In the 51st level south, the lode averages 14·5 dwt. over 3¼ ft., for a length of 406 ft. In McTaggart's section the results of development have been variable, some high-grade ore being occasionally found. In spite of these adverse conditions, the ore reserve is only 80,000 tons less than a year ago, standing now at 939,000 tons. The directors announced in February that it was intended to conserve the richer ore reserve as much as possible and that a reduced output of gold was being arranged.

Jibutil (Anantapur) Gold Mines.—This company was formed in 1911 by John Taylor & Sons, as the Jibutil Gold Mines of Anantapur, to work a gold mine in the Anantapur district, Madras Presidency, India. The property had been previously developed by the Nundydroog company. Additional capital was raised in 1912 and 1913 to provide metallurgical plant and to expand the scale of development. The report for the year ended September 30 last shows that 29,600 tons of ore was raised and treated for a yield of gold worth £31,934, as compared with 35,700 tons and £38,900 the year before. The total receipts were £32,398, and the working cost £35,003, leaving a loss of £2,605. The reserve on September 30 was estimated at 16,000 tons in the South Shaft section, which can only be broken on a small scale, and 4,800 tons at No. 1 Prospect Shaft. At the deepest workings in the South Shaft section, ore averaging 3 ft. in width and assaying 6·7 dwt. has recently been discovered, and further development is recommended. The time, however, is not propitious for raising new capital for the purpose, so the project has to stand over. At No. 1 Prospect Shaft, and at No. 5 Shaft, promising discoveries of ore have been made at shallower levels. At the former, the vein is 14 in. wide and assays 2 to 3 oz.; at the latter the vein is 2½ ft. wide and assays 32 dwt. At the present time, development is to be confined to these two points.

Tongkah Harbour Tin Dredging.—This company was formed eleven years ago under Tasmanian control, for the purpose of dredging tin gravel on the shore at Puket, Tongkah Island, off the coast of the Western Siamese States. Eliot T. Lewis is manager. The report now issued covers the year ended September 30 last. During this period all five dredges were working with little interruption, and the amount of ground treated was the highest on record. The total amount was 3,682,550 cu. yd., as compared with 3,363,750 cu. yd. the year before, and the production of tin concentrate was 1,188 tons as compared with 1,076 tons. The average yield per yard was 0·723 lb., as against 0·717 lb. The concentrate sold for £144,845, and the working profit was £77,266, out of which £8,463 was written off for depreciation and £37,500 was distributed as dividend, being at the rate of 25%. The income per yard was 9·44 pence, and the cost per yard exclusive of depreciation was 4·4 pence. During the year a drilling campaign proved the continuation of tin alluvium farther out to sea. The position of this ground is not so well sheltered from rough weather, and it will be necessary to provide a dredge of stronger build than any at present in use. The ordering of such a dredge is necessarily postponed at present owing to war conditions.

Gopeng Consolidated.—This company was formed in 1912 as a consolidation of the Gopeng and New Gopeng, which had been operating alluvial tin properties in Perak, Federated Malay States, since 1892 and 1903 respectively. The object of the consolidation was to facilitate the financing of a scheme, conjointly with the Kinta Tin Mines, for bringing a new supply of water at higher pressure for use in hydraulicking, the water being obtained from the Kampar river. We gave, in our issue of October last, a description of this new pipeline and the method of working the deposit by its means. The control of the company is in Redruth; James Wickett is chairman, and Osborne & Chappel are the managers. The report for the year ended September 30 last shows that 2,477,850 cubic yards of ground was treated, for a yield of 1,018 tons of tin concentrate, as compared with 2,212,800 yards and 1,083 tons the year before. The yield per cubic yard was 0·9 lb. as compared with 1·09 lb. The concentrate sold for £120,064, and the net profit was £88,996, out of which £69,259 has been distributed as dividend, being at the rate of 17%. Drastic regulations have recently been made by the Government of the Federated Malay States with regard to the disposal of tailing, and the company has been put to much expense for the construction of impounding dams, £12,000 having been spent in this way during the year under review.

Tekka Taiping.—This company was formed in 1913 as a subsidiary of the Tekka, for the purpose of acquiring an alluvial tin property at Taiping in the Larut district of Perak, Federated Malay States. The control is in Redruth, James Wickett being chairman. Osborne & Chappel are the general managers. Operations were started with a suction dredge, but a bucket dredge was subsequently installed. The report for the year ended October 31 last shows that 903,200 cubic yards of ground was treated by the bucket dredge, for a yield of 461 tons of concentrate. The receipts from its sale were £54,141, and the net profit was £37,831. The shareholders received £12,998, being at the rate of 20%, and £5,978 was written off as depreciation of the dredge. The company has yet to settle with the taxing authorities as to the excess profits duty payable, so a large balance is carried forward. The yield per yard was 1·15 lb., worth 14½d., and the working cost per yard was 4·63d.

Pengkalen.—This company was formed in 1907 by James Wickett, of Redruth, for the purpose of acquiring an alluvial tin property at Lahat, in the State of Perak, Federated Malay States. An electrically-driven suction dredge is at work, and electric power is sold to adjoining operators. The report for the year ended September 30 last shows that the output of tin concentrate was 155 tons, selling for £11,035. In addition £10,039 was received from sales of electric power, and £5,006 from tributers. The profit was £10,849, out of which £4,000 has been written off for depreciation of plant, and £3,500 has been distributed as dividend, being at the rate of 12½% on the 10% preference shares and 2½% on the ordinary shares, both of £1 each.

Arizona Copper.—This company has its headquarters in Edinburgh, and was formed in 1884 to work copper mines at Clifton, Arizona. Five years ago the smelting plant was rebuilt, and operations were planned on a larger scale so as to treat the big reserves of lower-grade ore more economically. During the last two years, two strikes have seriously interfered with the output. The report for the year ended September 30 last shows that work was continuous from October 1, 1916, to the end of June, 1917, after which date the men remained out until the end of the financial year, and did not resume until the end of October. During the period covered by the report, 1,178,087 tons of ore was raised, of which 49,657 tons averaging 5·7% copper, and mostly oxidized, was sent direct to the smelters, and 1,128,430 tons, averaging 2·43% copper, was sent to the concentration plant. The largest individual production came from the Humboldt mine, from which 628,136 tons was raised. Other leading producers were the Coronado, Clay, King, Horse-Shoe, and Longfellow North Extension. The output of copper was 21,241 short tons, of which 7,521 tons was sold as bessemer, and 13,720 tons sold as electrolytic or best selected. The accounts show a net profit of £785,052, out of which £137,804 was set aside for the redemption of debentures, £305,000 was placed to reserve, £24,531 was paid as preference dividends, and £303,979 was paid as ordinary dividend, being at the rate of 80%.

Le Roi No. 2.—This company was formed in 1900 by the late Whitaker Wright to acquire the Josie, Poorman, Annie, and other copper-gold properties at Rossland, British Columbia. After the historic collapse in the succeeding year, Lord Ernest Hamilton and his friends took control, and placed the management in the hands of Alexander Hill & Stewart. The vein system is complicated, and the ore requires much finding. We published a section of the workings in our issue of March, 1914. Production has been continuous, on a small scale, and dividends have been paid with a fair amount of regularity, though the rate of return is small on the Whitaker Wright capitalization. The report for the year ended September 30 last shows that 10,984 tons of ore, averaging 7·2 dwt. gold, 1·4 oz. silver, and 2·6% copper, was shipped to the smelters, selling for £25,129. Owing to the strike at the Crow's Nest coalfields, the Trail smelter, where the ore was treated, was closed from March to August, 1917. In the meantime the company sent shipments to Ladysmith, on Vancouver Island, but the cost of freight proved too high, and on the resumption of work at Trail, the old arrangement was renewed. A small shipment was also sent to the Granby smelter. During the time that no shipments were being made, ore-breaking was continued, and at the close of the financial year, 10,000 tons of broken ore was ready for shipment. The accounts for the year show practically an even balance.

MESSINA (TRANSVAAL) DEVELOPMENT CO., LTD.

Directors : C. F. H. Leslie (*Chairman*), J. A. Agnew, R. J. Frecheville, Lt.-Col. J. P. Grenfell. *General Manager :* A. B. Emery. *Secretary :* A. A. Kelsey. *Office :* 1, London Wall Buildings, London, E.C.2. *Formed* 1905. *Capital issued :* £181,788. 10s. ; debentures £250,000.

Business : Operates the Messina copper mine, in the Northern Transvaal.

The adjourned annual ordinary general meeting of the Messina (Transvaal) Development Company, Ltd., was held on March 20 at Salisbury House, London, E.C., Mr. C. F H. Leslie (Chairman of the company) presiding.

The Secretary (Mr. A. A. Kelsey, F.C.I.S.) having read the notice convening the meeting and the report of the auditors,

The Chairman said : With your permission we will take the report as read, and I will at once proceed to review the position of the company as shown by the directors' report, and will then endeavour to bring it before you up to date. I should like first of all to call your attention to an omission which has occurred in page 4 of the report in respect to the list of securities. There should have been included in that list 2,694 shares in the Santa Gertrudis Company. These shares were, in fact. sold after June 30, 1917, and realized the sum of £1,369. 0s. 3d. but the realization did not come into the year under review, so that the assets against the securities account, of £11,284, were, in fact, £1,369 more than as stated in the report. During the year under review we sold 20,850 shares in the Emba Caspian Oil Company, and, by this realization and the receipt of a payment of £1,484 from the liquidator of the Canadian Agency, the securities account outstanding was reduced from £25,000 to the figure mentioned in the report, namely, £11,284. By the receipt of the money for the sale of the Santa Gertrudis shares the securities account to-day stands at £9,915. 6s. 8d., which, as far as we can judge, is fully covered by the securities still held by us. Part of these securities originally consisted of shares and debentures in the Alberta and Southern Alberta Land Companies. These companies were, during the year, amalgamated and reorganized under the name of the Canada Land and Irrigation Company, Ltd., and that is the reason why the name of this company occurs for the first time in the list of securities. With regard to the profit and loss account, there is one new item in the account, namely, £35,000, under the heading of debenture stock redemption. This is the amount which has to be assigned out of the profits of each year toward the redemption of debentures. If no profit is made in any year then there is no obligation to repay debentures in that particular year, and it seems possible, I regret to say, that we may be in that position in November next, when the question of redemption in each year has to be decided. With the £35,000 available for redemption during the year ended June 30, 1917, debenture stock for £41,036 was redeemed, the average price of redemption being £85. 5s. 10d. per £100 of stock ; consequently the debenture stock now outstanding has been reduced to £208,964.

With regard to the amount carried forward—namely, £156,687—this is a very considerable figure, and it is only under the best advice obtainable that we have adopted this course. There are exceptional difficulties in the case of this company in arriving at a determination of excess profits tax, mainly on two points : (1) In agreeing the statutory capital of the company, and (2) in arriving at any proper conclusion as to the life of the mine. Any prematnre step in pressing for a settlement might be seriously prejudicial to the interests of the shareholders, but we hope shortly to be in a position to agree with the Inland Revenue authorites as to the statutory capital, and having done so the next step will be to go before the Board of Referees. Meanwhile, I am in the unfortunate position of not being able to tell you whether the £156,687 belongs to the company or whether it belongs fo the Government, or whether it is partly one and partly the other ; and it is for this reason that we have been compelled to keep this large sum of money in suspense.

I now come to the question of the revenue derived from the mine during the year. This matter has been very fully dealt with by Mr. Emery in his report, and the figures in the profit and loss account will show you that, notwithstanding the lower grade of ore produced from the mine, the revenue has not only been maintained, but rather increased, due partly to the higher prices realized for copper, namely, £143 per ton, as compared with £112 in the previous year, and partly to an increased production of ore, namely, 140,000 tons, as compared with 111,000 tons in the previous year. The assay value of the ore treated, however, fell from 5·43% to 3·98%, a very serious matter for a mine of this description. Under these circumstances, and having regard to the increased cost of labour, transport and material, the results will, I feel sure, have given you the greatest satisfaction.

This now brings me to the point at which we must survey the position since June 30 last, and more particularly to the question of ore reserves, and it is a great disappointment to know that, although we have pursued a vigorous policy of development, and have as a result of that policy developed considerable reserves of ore, namely, an increase of 60,000 tons so far as tonnage is concerned, yet the total copper contents of those reserves are only the same as at June 30, 1916, and the grade has fallen to 3·7% for the proved ore and for the whole reserves, including possible ore, to 3·5%, excluding Vogelzang ore, which is a negligible quantity. Meanwhile the price of copper has fallen, the cost of transport to the markets of consumption has further increased, the transport itself has been and is very precarious, and smelting charges are higher, and although our revenue up to the end of December last probably exceeded our expenditure by some £25,000, and there is some additional revenue to come in from the ore in transit at June 30 last, it is very doubtful to-day if we are working at a profit. Now, on every occasion on which I have had the pleasure of addressing you I have endeavoured to put this question of ore reserves in what seemed to me at the time, and seems to me to-day, its proper light. At times we have been much encouraged by finds of higher grade ore, as well as by the view of Mr. Graton, one of the great base-metal geologists of the world, whom we consulted, that there was no inherent reason why we should not find as rich ore in the lower levels as in the upper levels of the mine. Yet we have got to look at this fact, that ever since the year 1913, although the tonnage of the ore reserves has sometimes shown considerable increases, the average assay value of that tonnage has shown a constant fall from 10% in the year 1913 to 3·7% up to June 30 last.

Since the date of the report there has been no improvement in the assay-value of the ore, but we are still able to continue development and to hope that there may be a change in that condition. We have, however, got to contemplate the unpleasant fact that the life of the mine—and by that I mean the profitable life of the mine—may be approaching its end. In spite of these disappointments we are still continuing to work, but are much hampered by want of labour and shippings facilities, conditions which have only become acute since November last. The board is in continuous communication with the general manager in South Africa on all these points, which are not easy of solution, because to some extent the conditions vary from month to month, and we shall keep the mine in operation as long as we can see our way to do so, because this course holds out the best prospects of finding new and profitable ore supplies with the minimum amount of cost and dislocation. I have purposely put to you what I consider to be an unfavourable view of affairs, because I do not know—in fact, no one knows—in what respect we may expect any betterment of the position. On the other hand, should we be compelled to stop operations altogether, we have large liquid assets, easily realizable, and it might well turn out, after the adjustment of the many outstanding questions, due principally to war taxation, that there will be some considerable fund available for the shareholders after meeting all the company's liabilities. Under these circumstances it is the policy of the board to carry on the operations at the mine with a view, if not to profit, at any rate to the opening out of additional ore reserves, and to continue this course so long as we can do so at a reasonable cost; but it is equally our business to avoid frittering away, without any reasonable prospect of success, the very considerable liquid resources which we have accumulated, and we shall do our utmost to carry out this policy in the most economical manner possible, because we think we can in this way best protect the interests of the shareholders. I now move: "That the directors' report, together with the balance sheet and accounts for the year ended June 30, 1917, be and are hereby received and adopted."

Mr. R. J. Frecheville seconded the resolution, which was carried unanimously.

JIBUTIL (ANANTAPUR) GOLD MINES, LTD.

Directors: Captain W. Bell McTaggart (*Chairman*), Lt.-Col. Sir Donald Robertson, Vere H. Smith, John Taylor, Arthur E. Taylor, Lord Vaux of Harrowden. *Managers and Consulting Engineers:* John Taylor & Sons. *Secretary:* W. L. Bayley. *Office:* 6, Queen Street Place, London, E.C.4. *Formed* 1911, reconstructed 1913. *Capital issued:* £25,000 in preference shares, and £211,232. 10s. in ordinary shares, both of 10s. each.

Business: Operates a gold mine in Anantapur district, Madras Presidency, India.

The fifth ordinary general meeting of the Jibutil (Anantapur) Gold Mines, Ltd., was held on March 21 at 6, Queen Street Place, London, E.C., Captain W. Bell McTaggart, (Chairman of the company), presiding.

The Chairman, in moving the adoption of the report and accounts, said that during the year to September 30, 1917, 29,600 tons of quartz were treated, yielding 7,531 oz. of fine gold of a value of £31,934. In the preceding year 35,700 tons of quartz were crushed, the total production being 9,171 oz. of fine gold, worth £38,900. The expenditure amounted to £35,003 and the receipts to £32,398, showing a loss of £2,604. Though the total footage developed during the year was only slightly in excess of that of the previous year, being 1,402 ft. against 1,342 ft., the results, more particularly during the past few months, were more promising and seemed likely to lead to the opening up of fresh ore reserves.

Mr. Vere H. Smith seconded the resolution.

Mr. Henry C. Taylor said that the development work carried out in the past year amounted to 1,402 ft., an increase of 60 ft. on the previous year's record, and included 141 ft. of shaft sinking, which was practically identical with what was done in this respect in 1916. The financial position of the company had again governed the scale of operations, but stoppages of the Diesel power-plant for repairs had also retarded progress. The deeper workings at South shaft, where last year a discovery of better ore had been made at the 1,000 ft. level, could not be worked to advantage owing to compressed air not being available for underground hoists and rock drills. The general results of the mining work during the last few months were distinctly promising and were leading to the opening up of fresh ore reserves. This was especially the case at No. 1 Prospect shaft, where 4,800 tons of reserves were reported at September 30 last. At No. 5 shaft also a small tonnage had been provided for the mill, but the workings here were at present on a small scale and no true estimate could yet be made of the ore that would be stoped. At South shaft, which had in the past produced the bulk of the milling ore, the reserves remaining were now mostly low-grade, and amounted to some 16,000 tons. It was expected that they would be able to draw ore from the South shaft up to the end of April, when it was intended to stop work in this section until explorations could be carried on under more favourable conditions. A winze sunk 20 ft. below the 1,100 ft. level showed the reef to be 3 ft. wide, assaying 6¾ dwt., at this the deepest working on the property, and it was unfortunate that present circumstances did not allow them to continue exploration work there. When work at South shaft was suspended they would be dependent for milling ore on what could be profitably stoped from No. 1 Prospect shaft and No. 5 shaft workings, and as long as mill returns from these sources could be made to meet the costs the exploration of these promising sections would continue; but the scale of work could only be small in any event. As regards No. 1 Prospect shaft, at the last general meeting mention was made of the probability of improved values as the 400 ft. level was driven north, and he was glad to say that hope had been fulfilled. The latest advice (January 24) stated that a shoot of ore had been opened up at this level of a length of 104 ft., the lode width averaging 2½ ft., with an assay value of 1⅓ oz. of gold per ton; the end of the level, at 247 ft. from the shaft, showed, at that date, a fine lode 3 ft. wide, giving the rich assay of 5 oz. per ton.

The resolution was unanimously adopted.

SOUTH CROFTY, LIMITED.

Directors: Francis Allen *(Chairman)*, H. J. Meyerstein, Colonel H. A. Micklem. *Secretary:* T. Wallace Evans. *Office:* 6, Broad Street Place, London, E.C.2. *Formed* 1906. *Capital:* £50,000 in 200,000 shares of 5s. each.

Business: Operates a tin-wolfram-arsenic mine between Redruth and Camborne, Cornwall.

The twelfth ordinary general meeting of the shareholders of South Crofty, Ltd., was held on March 28 at Winchester House, London, E.C., Mr. Francis Allen (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts for 1917, said that the year had been one of great prosperity for them. The main source of the prosperity, of course, was the arsenic. Many years back they produced soot, and sold it at a price which, in their opinion, was an unfair one. The buyers of soot in those days were very limited in number and they did not ever give a fair price. From that time the directors decided to embark upon the refining of their own soot, and, as time proved, the course was a wise one. They produced a refined arsenic of high purity and first-class colour, and had registered the "Feathers" brand. They never had disputes either as to the quality or as to the colour. The price was far ahead of that of the previous year, and the price for the current year, 1918, would again show a very large advance. For 1918, in view of the contracts set, the price was bound to average over £100 per ton, but he thought the price had reached high water mark, and contracts set for the autumn of this year were somewhat lower than the contracts for the earlier part of the year. Tin was at a high price and was likely to remain so. The average for that sold this year was £178, and no doubt it would show a big advance over the year under review, 1917. Wolfram was up to £170, which was the standard price, and that also would remain so. Against those high prices the working costs were rising all the time. For the year under review they had certainly been moderate, considering all things, but they had been kept to that level partly by reason of the liquid assets and liquid cash that they had, which had enabled Mr. Paull to make very opportune bargains in forward contracts and by buying large quantities of material at low prices. Naturally as those contracts ran off and as the material became used up they had to purchase more at high prices, and therefore they must look for a rise in working costs yet. One of the large uses for timber was for the barrelling of the arsenic, and for the year 1918 they were already supplied with enough barrelling to carry them right through.

A new item in the accounts was the sum of £5,000 which was put on one side for the purpose of averaging the income tax. At present the five years' average on which they were working included the lean years at the commencement of the war, but as they moved on into these prosperous years the claims for income tax would mount up. It was a wise thing in a prosperous year to put this sum to reserve with the special object of meeting larger payments as they occurred. They had invested the £5,000 in War Loan. They had made two expenditures during the year which were unusual. One was a sum of £100 contributed towards the purchase of a sanatorium in Cornwall for the benefit of the many men returning from the war suffering from tuberculosis. They had also entered into an engagement to contribute £250 for three years to the Tungsten Research Committee set up by the Government with a view to trying to trace the losses of both tin and wolfram. With regard to Trevenson, they bought it with the special object of acquiring the freehold over what was expected to be the Rogers lode. Whatever lay beyond the lode they had recently passed through, and whether it was actually the Rogers lode or not, was not yet determined. The diamond drill would very soon go ahead and set all questions of that sort at rest. He wanted to take this opportunity of saying how much the board and the shareholders and Mr. Paull were indebted to Captain Taylor, the manager of East Pool, their neighbour, for the very kind and practical help given by means of his plans and all the information regarding his own lode in trying to help them to solve their own problem. He had given them splendid help and advice, and they took this opportunity of publicly acknowledging it.

Mr. Josiah Paull (the manager) then described the mine's position in detail. One or two improved developments had taken place since he wrote his annual report. With regard to the cross-cuts put out in the hope of cutting the extension of the Rogers lode, some three weeks ago it was decided to drive on the most promising portion of the lode passed through. Driving both east and west, but especially toward East Pool, the value in both tin and arsenic had very considerably improved. The average value of about 20 ft. driven east and west was 34 lb. of black tin to the ton and some 3% of arsenic over the width of the drive, or approximately 5 ft., while the main leader of the lode east for a width of about 2 ft. gave by vanning assay 84 lb. of black tin and some 8% arsenic. So far they were unable to say whether it was a continuation of the Rogers lode or not, but he did not mind what lode it was so long as it could be profitably worked, and so far it was very promising indeed. The first use of the diamond drill would be in the cross-cut at 225, where they proposed to put out a bore-hole 500 ft. or 800 ft. beyond the present end. There were great possibilities in this part of the property. One or two points in the western section were rather better than when he wrote his report, namely, the south lode, where they were driving east at the 225 level, and a drive west at the 205 fathom level. The former had improved considerably, and he hoped still to get further payable stoping ground, and the latter showed values well above the average of the mine. The relations between employer and employed were satisfactory. He had endeavoured to further encourage the employees to take a greater interest in their work by giving an extra monthly wage dependent on the mine working at a profit. The only condition imposed on a man or boy to get this extra wage was that he worked at least 23 out of 24 days per 4-week month. The vast majority of the 500 employees appreciated this concession, and only about 2% failed to carry out the condition.

The motion to adopt of the report and accounts was seconded by Colonel H. A. Micklem, and unanimously adopted.

It was proposed by Mr. Walter Towne and seconded by Mr. T. H. Evans, and unanimously agreed, that £500 be voted to the board as a bonus.

EAST POOL & AGAR, LTD.

Directors : H. Montagu Rogers *(Chairman)*, J. C. Gardner, J. M. Holman, W. J. Loring, C. Algernon Moreing. *General Managers :* Bewick, Moreing & Co. *Secretary :* J. F. Maynard. *Office :* Carn Brea, Cornwall. *Formed* 1913. *Capital issued* at December 31, £99,643 in shares of 5s. each.

Business : Operates tin-wolfram-arsenic mines between Camborne and Redruth.

The fifth ordinary general meeting of East Pool and Agar, Ltd., was held on the mine on April 8, Mr. H. Montagu Rogers (Chairman) presiding.

The Chairman, in moving the adoption of the report and accounts for 1917, said that the receipts had risen from £125,513 in 1916 to £178,710 last year, and were double those of 1915. The profits last year were £59,651 compared with £22,485 in 1916 and a loss of £972 in 1915. The expenditure had increased proportionately. Prices of all materials had bounded up. Mine development cost £17,910 last year against £14,110 in 1916; underground workings £48,241, against £45,972; surface working £37,683, against £31,004, and dues £5,677, against £3,882. On the credit side they found that last year they sold 943½ tons of tin which realized £129,263, giving an average price of £136. 19s. 11d., against 914 tons in 1916, which realized £94,495, giving an average of £103. 7s. 5d.; wolfram in 1917, 71 tons, amount realized £12,875, average price £186. 4s. 5d., against 100½ tons in 1916, which realized £17,542 and gave an average of £174 9s. 5d. Last year 488¾ tons of arsenic fetched £34,062, giving an average of £69. 13s. 8d., as compared with 526½ tons, which realized £12,434 and gave an average of £23. 2s. 3d. in 1916. With the exception of copper last year's prices were the highest received for all products. The produce of tin and wolfram last year was 29·41 lb., 1916, 27·93 lb., and in 1915, 19·92 lb. After charging the whole of the expenditure on development for the period and depreciation on the main shaft and machinery, 12½%, the profit was £59,651, to which must be added £1,284 from last year, making a total of £60,936. The four interim dividends paid absorbed £19,078, leaving a disposable balance of £41,857. The directors proposed to pay a final dividend of threepence per share, making a total of 1s. 3d. for each 5s. share, or 25% for the year, and to carry forward £36,875. The directors had considered the advisability of paying dividends half-yearly instead of quarterly and they had come to the conclusion, having regard to the depleted clerical staff, to pay dividends in future on July 1 and January 1.

In view of future expenditure contemplated regarding the increasing of the machinery and plant of the mine and more extensive underground development, which would involve large additional capital expenditure, the directors considered it prudent to increase the cash reserve of the company and to capitalize £20,000 of the undivided profits of the company. They, therefore, recommended the shareholders to increase the capital of the company to £120,000 by the creation of 80,000 new shares of 5s. each. The shares would be distributed to the shareholders in the proportion of one fully-paid share to every five shares held by them. This would be equal to another 20%, or 45% for the year, but if they looked at it from a market point of view, it was something over 100%. The policy recommended by the board was to build up a cash reserve and provide for future contingencies and anticipated outlays. To guard against any possible contingency, an electrically-driven pump had been erected, and now they felt comparatively safe. The position and general output of the mine, both on surface and underground, was satisfactory. The dressing plant was kept up-to-date, and they were constantly making experiments and increasing the efficiency under the able supervision of their inventive genius and excellent superintendent, Mr. Taylor.

They had recently purchased the mineral rights of the Tehidy estate, and they had become the owners of East Pool, Carn Brea, Barncoose, and Wheal Tehidy setts, including the freehold of all damaged land within those setts, and the land at Tolvaddon stamps on which their dressing-floors stood. This had freed them from future dues, and on the East Pool section of onerous covenants. The Carn Brea machinery and plant known as Highburrow East had also been purchased, as had twenty-five acres of timber in Tehidy plantation, which had been paid for out of the accounts before the shareholders.

Mr. C. A. Moreing seconded the resolution. He said that at the last meeting he drew attention to the improvement in the attendance of the miners, and it was now with considerable pleasure he had to report a further improvement. The shifts lost in 1917 represented 6% of the total number of shifts that could have been worked, and in 1916 the percentage was 6·9. This was a very satisfactory feature and he was hopeful that the number of lost shifts would continue to show a reduction. This was not only of importance to the men, but the district benefited, and the mine, which was now recognized as being of national importance, benefited as well. Particulars of the development work carried out of the Rogers lode during the year were set out in the general managers' report. He desired to draw attention to the East drive of Rogers lode at the 190 fathom level. The lode struck an elvan course at about 345 ft. It became pinched as they followed the narrow turn, and the values disclosed were low and unpayable. A diamond-drill put out north intersected payable values clear of the elvan at a point about 120 ft. from the drive, and from all appearances these values formed one of the lodes, which at this place was about 28 ft. wide. This work emphasized the advantage of the company owning a diamond-drill which could be used for clearing up doubtful points of this kind, as well as general exploration. The machine had done satisfactory work during the year, and the cost per foot of drilling was 11s. 7d., against 13s. for the previous twelve months. Although during last year the development work was greater than in 1916, a considerable portion of this was for the purpose of further opening up for stoping ore which had been previously developed. Shortage of labour had considerably interfered with the development programme which they should have put into effect. The development of the eastern portion of the property, which they felt confident possessed great possibilities, by working east from the present ends in Agar, had also to be left in abeyance for the same reason. The electrically-driven pumps were considered advisable to safe guard their position, as some of their most important workings on the Rogers lode were dependent upon the almost continuous working of the pumping plant.

The motion was carried unanimously.

GOPENG CONSOLIDATED, LTD.

Directors: James Wickett (*Chairman*), F. Douglas Osborne (*Vice-Chairman*), W. R. H. Chappel, Martin Edwards, S. Howard Lanyon, Cuthbert J. Pike, R. H. Savory. *Managers:* Osborne & Chappel. *Secretary:* Tom Wickett. *Office:* Redruth. *Formed* 1912. *Capital:* £395,798.
Business: Operates alluvial tin properties in Perak, Federated Malay States.

The fifth ordinary general meeting of Gopeng Consolidated, Ltd., was held at Redruth, on April 3, Mr. James Wickett (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts for the year ended September 30 last, said that the statement of accounts was the most satisfactory one they had ever presented. The profit was £88,996. They had a balance in hand of about £17,000, so that they had £105,000 available, out of which they divided £52,000, leaving an available balance of £53,000. For the pipe-line and other things they wiped off £9,493, and placed £10,000 to a reserve for income tax. They now proposed paying a bonus of 10d. per share, absorbing £16,490. After the year's working and wiping off fairly large amounts they were left with an available balance of £17,237. They had returned their tin at £38. 10s. 3d. a ton. In the early days they returned tin for £25 a ton. They had had, in the year just passed, to spend a considerable sum of money to meet the altered conditions under which the property was being worked. However, they were left a profit of £79. 6s. 3d. a ton, and at the present time they were making a profit considerably in excess of that. He had carefully looked through the financial statement for the year and found that they had investments at cost of £59,000 on September 30. To-day the investments at cost were over £80,000. He did not think they had been unwise in the Straits companies generally in the way in which they had parted with their money. They had at the present time £200,000 loaned to the country, and they might congratulate themselves that they were in a position to lend a hand when money was badly wanted. The original shareholders of the company who were left were still the very largest shareholders. When Gopeng was started it was a very small concern, and there were only 13 shareholders originally, and now they were about 800. He was thankful for the fact that a materially large share of the profit that had ensued from the company had stuck to Cornwall.

Captain F. Douglas Osborne, one of the managers, in seconding the resolution, said that there was one matter the chairman referred to: that the working costs per ton of tin recovered in the early days was £25, and that now it was nearly £38. There was, however, good reason for that. When they started they had alluvial workings which were very rich. It was right on the surface, and they were at no expense in saving the tin beyond just mining the ground to a lower level. At the present moment they were working in many places at a depth of 120 or even 150 ft. below the original surface. When they worked the original surface they filled up valleys, and now they had to lift up what they were dealing with to a height to get rid of the tailing. A large proportion of the water supply was used in the work of elevating that ground. There was also at the present time the question of dealing with the tailing from the mine. There would be little or no difficulty in dealing effectually with the heavy debris, but with regard to the final slime, owing to recent drastic steps which had been taken by the Government, a considerable sum of money would have to be spent in the future in the erection of tailing dams and settling areas for the purpose of impounding all but the infinitesimal quantity of slime which the Government was now prepared to let them run away. During the year the sum of £12,000 was expended on dams and relative works, amounting to 32% of the total expenditure, or 1·17d. per cubic yard. It did not require any comment from him to demonstrate that it was only natural their working costs, and the costs of producing tin, must have increased when they had this extra expenditure forced upon them. There did not appear to be any probability of relief in this respect in the near future, but with the property they had—its extent and value had been demonstrated by the work since the new installation was completed—there was no reason to begrudge the money necessary to expend on these conservation works in the future. At one time during the year the position became very acute with regard to tailing, so much so that it was feared it would be necessary for either Mr. Chappel or him to go out there; but fortunately Mr. Mair, the resident partner, had proved himself quite capable of dealing with all questions that arose. He had dealt with the matter in a masterful way. He fought all departments there individually, and eventually collectively. He argued that it was impossible to come to any reasonable arrangements until all departments interested consulted and came to some basic proposition, and he succeeded in this. The whole tailing question would probably be settled now, he told them, fairly for them, and definitely for the future, so that out of the evil that seemed to be confronting them considerable good had arisen.

As regards the history of Gopeng, it was interesting to recall that the concession was gained by Irishmen, (he was an Irishman himself), and the Irishmen tried to get a start for financing it in other places, and it was only when they came to Cornwall that they could find men who were speculatively inclined and willing to take a hand in what appeared to be a wild gamble. Nothing had been conceived in the way of mining of this description before. It was an entirely novel experiment. A few Cornish friends of Mr. Wickett came in, and none had ever regretted it. The scale of operations had grown gradually. The last increase was, of course, very much the largest, and it took a lot of time and a good deal of patience and a tremendous lot of perseverance, to persuade the interests concerned that it was better for them to put up the money and face this big expenditure than to go on as they had been doing. The value of the advice his firm gave with regard to that, and the pressure brought to bear on everybody to whom he spoke of the new Gopeng Co. and the Kinta Mines, had been amply demonstrated. Had it not been for the increase in the water supply, and the power now available, those three companies would be in a very bad position to-day. In fact, their working would be hampered to such an extent that, instead of having to congratulate themselves on a prosperous year, they could probably have had to explain away the reason why shareholders had not their usual dividends.

The resolution was carried unanimously.

TEKKA-TAIPING, LTD.

Directors: James Wickett (*Chairman*), J. W. Horton Bolitho, F. Douglas Osborne, J. L. Holman. *Secretary:* Tom Wickett. *Office:* Redruth. *Formed* 1913. *Capital:* £65,000.
Business: Operates alluvial tin property in Perak, Federated Malay States.

The fourth ordinary general meeting of Tekka-Taiping, Ltd., was held on April 3, at Redruth, Mr. James Wickett (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts for the year ended October 31, said that they brought forward from the previous year a balance of over £20,000 from which they had to pay excess profits amounting roughly to £14,000. That left £6,000. During the year they made £37,000 profit, and altogether they had £44,000 available. They declared four dividends of 1s. each per share and wiped off about £6,000 for depreciation, leaving £25,540 in hand. The returns had been reduced, as they knew they would be when they stopped the suction dredge, because it was rather too expensive to work it. They paid the Straits Government last year as royalty £8,271. 19s. 10d., so out of a very large profit, through circumstances over which they had little or no control, the shareholders had not received a very large sum. In fact, they had been hit by excess profits. The cost of returning tin was £37. 15s. 4d., and the profit made was about £78 a ton. His opinion was that this was one of the best concerns in the East. Here was a property of 2,000 acres, scarcely scratched yet, with great possibilities.

Mr. J. L. Holman seconded the motion.

Capt. F. Douglas Osborne said that the experience with the suction dredge showed that the ground was suitable for treatment by bucket dredge. It was hoped that the operation of this dredge would provide sufficient money, not only to regularly satisfy the shareholders in the way of dividends, but at the same time accumulate funds to put in further bucket dredges. They were only just carrying on, and under fairly adverse conditions. It was practically impossible to get the necessary spares to keep the present dredge in constant operation. But this was a fairly good machine, and he felt pretty confident they would carry on until they could again get spares. The management out there had had the prevision to stock supplies of spares to carry them on for about a year. Some might complain that they did not get big dividends, but the shareholders got 20%, and, after all, that was not very bad. With an issued capital of £65,000 they made a profit of roughly £38,000. That was not bad either. It enabled them to give something to the Government to help carry on the war, in the form of excess profits. They had reason to congratulate themselves that they had been in the position to assist the country, even though in a small way.

The resolution was carried unanimously.

PENGKALEN, LTD.

Directors: James Wickett (*Chairman*), J. W. Horton Bolitho, S. M. Abbott, F. D. Bain, Stanley Wickett. *Secretary:* Tom Wickett. *Office:* Redruth. *Formed* 1917. *Capital:* £90,000 in ordinary shares and £10,000 in preference shares.

Business: Operates an alluvial tin property in Perak, Federated Malay States.

The tenth ordinary general meeting of Pengkalen, Ltd., was held on April 3, at Redruth, Mr. James Wickett (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts for the year ended September 30, said that the statement of accounts was the best they had ever been in a position to present, and they were in a fairly satisfactory financial position at the end of the year. They had nearly £9,000 in investments, and a decent sum in hand besides. As far as he could see, the outlook for the company was a very satisfactory one. The report showed that the output of tin concentrate was 155 tons, selling for £11,035. In addition £10,039 was received from sales of electric power, and £5,006 from tributers. The profit was £10,849, out of which £4,000 had been written off for depreciation of plant, and £3,500 had been distributed as dividend, being at the rate of 12½% on the 10% preference shares and 2½% on the ordinary shares both of £1 each. Since they last met they had had the misfortune to lose a particular friend, and one of the best directors ever connected with the group of Malay mines, in the person of Mr. John H. Bain. He was one of the best business men he ever met, and he did not think that he ever lost a business friend with greater regret than in him. Mr. Bain and his father had been connected with all their companies for 26 or 27 years. The loss was not only theirs, but to the district in which they lived.

Mr. J. W. Horton Bolitho seconded the motion.

Mr. W. R. H. Chappel, one of the managers, said the report gave the result of the past year's work, and corroborated the forecast he made at the last annual meeting, that they might expect better returns this year. The report called for very few remarks, but there was one point that he would refer to. As soon as the war was over it would be necessary for them to further increase the capacity of the generating plant by putting in a further turbo-generator, as the one they put in three or four years ago had proved itself very reliable and efficient, and had been the cause of the company reaching its present satisfactory position. As the chairman pointed out, the company at the end of last year had a credit balance of well over £10,000. That had been largely increased during the last six months by the returns from the mine, but he did not think they would find the directors justified at the end of the year in largely increasing the dividend, because the better policy for the company would be to increase the power at the generating station, by which means they would be able to get larger profits in the years to come. The prospects continued to be fair, and they could look for a steady revenue from the mine.

The motion was carried unanimously.

Mr. W. Byrant proposed, and Mr. W. J. Dixon seconded, the re-election as directors of Messrs. F. D. Bain and Stanley Wickett, Mr. Bain having succeeded his brother on the board. The motion was carried unanimously.

TIN FIELDS OF NORTHERN NIGERIA, LTD.

Directors*:** S. R. Bastard ***(Chairman), F. N. Best, C. G. Lush. ***Secretary*:** A. J. Culley. ***Office*:** Friars House, New Broad Street, London, E.C. ***Formed*** 1909. ***Capital issued*:** £70,007.
***Business*:** Operates alluvial tin properties in Northern Nigeria.

The fourth ordinary general meeting of the Tin Fields of Northern Nigeria, Ltd., was held on March 18 at Friars House, London, E.C., Mr. Segar R. Bastard (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts, said that since March 31, 1917, the high price of tin, coupled with an increased output and low working costs, had placed the company in a satisfactory position financially, and the directors considered that shareholders should have the opportunity of themselves investing in war loans rather than the directors themselves making these investments for them. The proposed distribution involved the payment of £7,000, and still left an ample balance in hand for continuing the proper working of the properties and the securing of others should the opportunity arise and should it be deemed necessary. They were not aware of any likelihood of additional capital demands, as the property was well equipped for all requirements, and tin was still coming forward regularly and realizing good profits. They had now heard that all mining rights referred to in the report had been granted, and a further mining right had also been granted to them, making 19 in all. The manager wrote under date January 31 that the new camp on the Upper Fedderi areas was now in working order and that prospecting was still going on and would take some little time to complete. So far results gave encouragement. They had in Mr. Pope, the late manager, a very capable and hard working man, and they had been most fortunate in obtaining an equally good man in their present manager, Mr. Clemens. He was going to ask them to propose a vote of thanks to Mr. Clemens, and, further, to vote him an honorarium of £200 as a token of their appreciation of his services. Since this report was published they had had the excellent return for February of 15 tons, which made a total of tin oxide won of 120 tons for eleven months of a high grade and at a low working cost. When Mr. Pope returned he informed the board that the Lower Fedderi area was practically exhausted and that in the coming April it should be surrendered. Mr. Clemens, who was a very good prospector, had contradicted this statement, and informed them that they had in sight another two years' work, with very good prospects of further deposits being discovered, and they had withdrawn the notice of surrender.

Mr. Frank N. Best, in seconding the adoption of the report, said it was gratifying to hear that Mr. Clemens spoke so well of the property. When he was there in 1912 he formed a very high opinion of the property. His opinion might not be worth much, as he was not a mining engineer, but he had spent previously several months on the Naraguta property and seen the amount of tin opened up on that property, and was therefore able to compare the one with the other. He could say now that in his opinion a great amount of tin would be found in the Fedderi Valley.

The resolution was carried unanimously.

TWEEFONTEIN COLLIERY, LIMITED.

Directors*:** Lord Oranmore and Browne (Chairman***), W. E. Lawson Johnston, L. Kessler. ***Secretaries*:** Henderson's Transvaal Estates, Ltd. ***Office*:** Egypt House, New Broad Street, London, E.C.2. ***Formed*** 1907. ***Capital issued*:** £75,000 in preference shares and £60,000 in ordinary shares, both of £1 each.
***Business*:** Operates a colliery in the Middelburg district of the Transvaal.

The eleventh ordinary general meeting of Tweefontein Colliery, Ltd., was held on March 25 at Egypt House, London, E.C., Lord Oranmore and Browne (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts for the year 1917, said that the balance of profit, £26,431, was slightly higher than last year, and to this there fell to be added the sum of £11,189 brought forward, making a total of £44,620. Out of this the board had already paid an interim dividend of 6% on the ordinary shares and the cumulative dividend of 6% on the cumulative preference and participating shares, absorbing £8,099, and in the report they recommended the payment of a final dividend at the rate of 19% on the ordinary shares, making a total dividend of 25%, and a further dividend at the rate of 4% on the cumulative preference and participating shares, making the total dividend on these shares 10%, the maximum to which they were entitled. After payment of these final dividends a balance of £22,120 remained to be carried forward to the current year's account. The coal sold during 1917 was 444,115 tons, as against 436,898 tons for 1916. Last year he drew their attention to the increased demand for South African coal for bunkering and export. This improvement continued during the year 1917, the figures as compared with the year 1916 being as follows: Cape Town, 1917, 336,685 tons, as against 295,505 tons in 1916; Delagoa Bay, 1917, 872,802 tons, as against 746,091 tons in 1916. He was sorry, however, to inform them that since he last had the pleasure of addressing them the South African railways had again raised the railway rate on bunker coal to Cape Town, Durban, and Delagoa Bay by a further 4s. a ton, making a total increase in two years of 10s. a ton. The increase did not apply to coal supplied for export. Their contracts for bunkering were made subject to rise or fall of railway rates, and there was reason to fear that the heavy increase in the rates during the last two years might result in a falling off in the demand for bunker coal at South African ports. The Transvaal Coal Owners' Association, of which the company was a member, had been renewed for a period of five years from July 1 next. This association dealt with the bulk of the coal produced in the Transvaal, and during the year 1917, 5,599,684 tons passed through its books. Taxation, both in this country and in South Africa, continued to take its toll of them. Excess profits for 1915 and 1916 came into this year's accounts, while they also had to pay a new tax on dividends which had for the first time been imposed in South Africa. Notwithstanding this they were glad to have been able, in spite of the heavy increase in cost of labour, stores, and taxation, to maintain their output and dividends at the same rate as heretofore.

Mr. W. E. Lawson Johnston seconded the motion, which was carried unanimously.

H.E. PROPRIETARY (NEW), LTD.

Directors : F. H. Hamilton *(Chairman)*, Major F. B. Lawson, L. Ehrlich, A. L. Secretan, E. Turk. *Secretary :* William Smith. *Office :* 10 & 11, Austin Friars, London, E.C.2. *Formed* 1912. *Capital issued :* £174,163 in shares of 10s. each.
Business : The financing of and investment in mining and other properties.

The ordinary annual general meeting of the H.E. Proprietary (New), Ltd., was held on April 3, at Salisbury House, London, E.C., Mr. F. H. Hamilton (the Chairman) presiding.

The Chairman, in moving the adoption of the report and accounts, stated that the most important item of business was the acquirement of the Farm Klippoortje, in the Heidelberg district of the Far East Rand. This farm had been purchased by himself and Messrs. Ehrlich and Turk and they were selling it to the company. He would ask the shareholders to confirm this transaction. After reviewing the other business of the company and the accounts, the Chairman called on Mr. A. L. Secretan, one of the directors, to second the resolution and to explain the Klippoortje transaction.

Mr. A. L. Secretan said that they, like everybody else interested in South Africa, had watched recent developments on the Far Eastern Rand closely, and realized that the developments on the Sub-Nigel, which was separated from Klippoortje only by the property known as Maraisdrift, owned by the Rhodesia Exploration Company, had a very direct bearing on its prospects. They also knew that other discoveries during the last twelve months in the immediate neighbourhood of Klippoortje, notably on Spaarwater to the west, and the work proceeding on the southern portion of Klippoortje, and on the Heidelberg Town Land on the west, had aroused a great deal of attention both here and in South Africa, and that there was a growing body of evidence to show that Klippoortje contained one, if not two, of the reefs from which a large and increasing proportion of the profits of the Rand were coming at the present time. They consulted their technical adviser, Mr. E. T. McCarthy, and they also had the advantage of consulting a report which another engineer, Mr. A. Hooper, made some time ago, when less was known about this part of the Rand than was the case now. Subsequent developments had confirmed Mr. Hooper's views in a very striking manner. There was a difference of opinion among engineers regarding this district. One view was that the reef worked in the Sub-Nigel was the Van Ryn-Modderfontein reef ; the other view was that the Van Ryn reef was a separate reef, slightly to the dip and overlying the reef now being worked. Into these theories he did not propose to enter, because they were advised that there was no reasonable doubt that the reef worked by the Sub-Nigel traversed the whole extent of this portion of Klippoortje at an easily workable depth. If, as was maintained, they had another reef in addition, so much the better. The recent history of the Sub-Nigel mine was familiar to many of them. The value of its ore reserves had more than doubled during the last few years, and its dividends had increased five-fold in the same period. The area they proposed to acquire was freehold, and was equal to 3,241 English acres. The exact number of claims to which the owners were entitled on proclamation could not be exactly stated, but the mynpacht was equal to 428 claims. Their immediate neighbour to the east was the Maraisdrift, and certain negotiations were being conducted for instituting a joint and comprehensive scheme of boring which would enable them not only to locate their mynpacht to the best advantage, but would facilitate the flotation that they eventually contemplated.

The motion was carried unanimously.

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EDITORIAL

SEVERAL readers have suggested that Mr. Goodchild's articles on the Evolution of Ore Deposits now appearing in our pages assume a greater acquaintance on their part with modern physical chemistry than most engineers are likely to possess. In particular, "solid specific volume" appears to be giving them trouble. We have therefore asked the author to embody in the article in this issue a short exposition of the principle. The argument is thus made clearer and easier to follow.

DEVELOPMENT of water power in Scotland has received a severe set-back by the refusal of the House of Lords to sanction the scheme of the British Aluminium Company involving the utilization of the waters of Lochs Treig and Laggan. It appears that the landowners and the local county council are both in opposition, while several members of the House think that enterprises of this nature should not be left to private enterprise but be made national in character. This attitude is quite at variance with business principles, and also with the views of the Board of Trade and the Ministry of Munitions.

TWO articles in this issue deserve special mention. That by Mr. R. C. Sharp describing tungsten occurrences in the Argentine gives information on a subject on which little or nothing has hitherto been published. The other article refers to the use of the Thompson-Davies magnetic separator in connection with tin-wolfram concentrates at Storey's Creek, Tasmania. This machine is made by the Rapid Magnetting Company, a Birmingham firm that has sold magnetic separators for many years for employment in connection with other substances than ores. It is good to know that an English machine is making headway in a field where German machines used to prevail.

ACCORDING to the authorities at the British Museum of Natural History the malaria mosquito has made its appearance in England, and a chart that has been issued indicates the suspected zones. The introduction of the mosquito or the malaria is attributed to war traffic from malaria-ridden regions such as East Africa. This country has always had its mosquitoes, and in the old days its malaria and ague as well. With the disappearance of the latter, the mosquitoes had no germs to carry from one subject to another. Thus they acquired an undeserved reputation for being harmless. It seems, therefore, that the malaria germ has been re-introduced by the returning invalided soldiers, and that it is being disseminated by the supposedly harmless species of anopheles.

SIR Charles A. Parsons, of steam-turbine fame, delivered the May lecture of the Institute of Metals on May 2 to a crowded audience assembled in the lecture theatre of the Institution of Civil Engineers. In this lecture he described his experiments and researches in connection with the formation of diamond in an iron matrix. He showed that diamond could not be formed from graphite by great heat and pressure, but that crystals could be produced by reduction from occluded gases such as carbon monoxide at pressures and temperatures that are not out of the way. We shall quote him in detail next month.

IT is gratifying to be able to record that the Murex Company has joined the list of dividend payers. The company was formed in 1909 to work the Lockwood-Samuel wet magnetic separation process, but though the scientific interest was great, commercial success did not arrive. Mr. George J. Joseph acquired control two or three years ago, and under his auspices profitable business has been secured. A small income is received from royalties, but much more is made by the operation of a plant in the east end of London, where tin-wolfram and other complex concentrates are separated. Last year the business was still further extended by the erection at Rainham, on the Thames, of furnaces for producing ferro-tungsten and plant for the production of tungsten powder. The credit for the success of the company from the technical side is due to the manager, Mr. H. A. Green.

THE annual meeting of the Institution of Mining and Metallurgy held last month was as usual the pleasantest of functions. We refer elsewhere to Mr. H. F. Marriott's presidential address, the excellence of which made his audience wish that he would write at greater length on South African mining subjects. The votes of thanks to the council and to the retiring president, Mr. Edgar Taylor, afforded Messrs. H. F. Collins, William McNeill, Walter McDermott, and S. J. Speak the opportunity of voicing the appreciation of many services efficiently rendered. Mr. Edgar Taylor has occupied the presidential chair longer than anyone else. He served as president for two years some time ago, and toward the end of 1916 responded to the invitation to return to the position on Sir Richard Redmayne's resignation, so that his total tenure of the office has been 3½ years. Mr. Taylor makes an acceptable presiding officer at a meeting, and his suave and dignified manner marks him as an ideal negotiator of difficult problems. To the regular votes of thanks, or as a specific mention in the general vote of thanks to the staff, we should like to add an acknowledgment of the services of the librarian, Mr. F. O. Leaning, who is always approachable and helpful to both member and visitor.

The Dolcoath Meeting.

We do not wonder that boards of directors of mining companies should occasionally feel contemptuous of shareholders, for at many a meeting some ignoramus or disgruntled individual will rise to offer absurd comments. At one meeting a shareholder will ask the board why the market quotation has dropped so severely, and cannot the directors do something to restore the position, though it is evident from the issued report that the mine is approaching its end. On another occasion a shareholder grumbled at the remuneration of the technical adviser, when he really ought to have felt himself lucky to have the services of so capable a servant. At the Dolcoath meeting the fun came from a countryman of broad dialect, who thought it scandalous that debentures should be issued to provide funds to purchase the freehold of the properties, thus taking £6,000 out of the profits which should belong to shareholders, in order to pay debenture interest. He was surprised and hurt at the laugh that went round the room, and we are not quite sure that he was convinced when he was told that, by buying the freehold, shareholders had got rid of royalties averaging £8,000 a year. Faithful and intelligent shareholders deplore these ridiculous exhibitions.

Dolcoath is suffering at present from a lack of men for development work. Not being a producer of wolfram, the military authorities take a larger proportion of miners than they do from East Pool and South Crofty. With this shortage of labour, Mr. Arthur Thomas has found it impossible to test the mine in depth. With a restricted number of profitable points, and with fewer men, the yearly tonnage is now about 70,000, as compared with a previous average of about 100,000. Under present conditions the cost of mining has advanced seriously, and now stands at over 35s. per ton as compared with 26s. a year ago, these figures not including lord's royalties or allowance for depreciation. At the meeting of shareholders Mr. Thomas described the prospecting work now being done by diamond drill on the 170 fathom level with the view of intersecting the northern series of lodes. These lodes are the faulted continuation of the lodes worked in South Crofty, and they may be expected to contain the same complex ore, with wolfram and arsenic in addition to tin. At the present time no wolfram is being produced at Dolcoath, but during the last six months substantial amounts of arsenic have been recovered. With regard to the future of the enterprise, as Mr. Thomas said, they had to keep on working and to cultivate the spirit of hopefulness. The new ground just acquired offers excellent chances for discovery, and development will be commenced whenever labour is available.

The Rand Ore in Depth.

Many interesting Presidential Addresses have been delivered at the annual meetings of the Institution of Mining and Metallurgy. In recent years we remember particularly those of Mr. H. Livingstone Sulman, Dr. F. H. Hatch, and Sir Thomas K. Rose. Last month Mr. Hugh F. Marriott joined the front row of lecturers by giving a concise review of the methods of attacking mining problems on the Rand during the last quarter of a century. Though his address was naturally strictly technical, seeing that it was delivered to a technical audience, it was nevertheless couched in such language as to be perfectly intelligible to the average man who follows the fortunes of mining. For this reason the address deserves the attention of a wider circle of readers than is provided by the membership of the Institution, and we have therefore given excerpts on another page. Mr. Marriott is exceptionally qualified to write on this subject, for he has been continuously connected for 27 years with the leading house on the Rand, formerly known as the Eckstein-Wernher-Beit, and now as the Central Mining-Rand Mines, group, and since the retirement of Mr. Hennen Jennings he has been the house's consulting engineer in London. We have quoted the sections of his address relating to the prospecting of the deep levels by bore-hole and otherwise, the reorganization of underground working and of hoisting, the sand-filling and packing of exhausted stopes, and the investigations with regard to the persistence of values in depth. Owing to exigencies of space we have had to omit his remarks on the comparative advantages of various types of shaft and on ventilation. His statement with regard to the centralization of hauling and hoisting methods is particularly timely, for it is in this department that the greatest opportunity has been presented for a reduction of underground costs, and there are many openings for further improvements in this direction. We may express the hope that Mr. Marriott will enlarge on this subject in a paper dealing with the matter in detail. But by far the most important part of his address was that devoted to a consideration of the gold content of the ore in depth, for he presented figures never before published, and obtained at the expenditure of a vast amount of labour and research. The discussion as to the persistence of ore in depth is of course perennial. While it is generally found that gold deposits of Tertiary age do not go down far, those dating from Paleozoic times are often characteristically persistent. Another law has also been laid down by Dr. Malcolm Maclaren that persistence or impoverishment in depth is governed not so much by depth but by changes in the wall-rock. The third point, applicable chiefly to the Rand, relates to the origin of the gold, whether the deposit is a fossil placer, or whether the gold has been introduced by infiltration from below, or from elsewhere by a secondary solution. A little consideration of these three items will show that we may expect the Rand deposits to give fair promise in depth, and that the abandonment of operations will depend more on capital and current costs than on impoverishment of the ore. The difficulty of arriving at an accurate judgment on this matter in connection with the Rand is increased by the great length of outcrop, and the wide variations in gold content laterally, both at surface and in depth. There is in fact such a great array of conditions and occurrences that the exponents of every theory can find data that suit their particular purposes. Thus the champion of the principle of impoverishment could point to the rich ore near the surface of Crown Reef and the poorer parts on the dip in the deep levels of Crown Mines; while on the other hand the optimist could show that City Deep has a big stretch of rich ore below the Wolhuter and Goch, two mines that have not been noted for their profits. Under these circumstances the only satisfactory basis for judgment is a compilation of figures over a considerable stretch of reef, divided into horizontal zones from the surface downward. This compilation has been made by Mr. Marriott on a stretch of eight miles of Main Reef Leader in the Central Rand, extending from Crown Mines on the west, through Robinson, Ferreira, City & Suburban, and City Deep, to Nourse. Some of the early records of mining at the surface are lost, and the records at other mines, such as the Langlaagte and New Goch, are not available. Nevertheless the figures are so extensive and complete as to permit of reliable deductions. Mr. Marriott has plotted the results on a coloured map showing the blocks according as they assay on an average over 0s., 5s., 10s., 15s., 20s., 25s., 30s., 35s., 40s., and 50s., and he has also prepared a table averaging all these blocks in their respective zones of 1,500 ft. in depth. It is impossible to reproduce this map in our pages, but we give the table elsewhere. From the table it will be seen that the outcrop zone is substantially the richest, assaying 44s. 9d. as compared with the general average of 34s. 2d., and to that extent the impoverishment school score a point. A much more important piece of evidence, however, as regards the future of the Rand comes from a consideration of the next five zones, though perhaps the lowest zone might advisedly be omitted from the argument for the present seeing that it has been developed only to a limited extent. The second zone averages 31s. 2d., the third 37s. 1d., the fourth 32s. 5d., the fifth 29s. 10d., and the sixth 30s. 8d. It will be seen that the third zone shows a higher average content than the second, and this fact to some extent counterbalances the argument based on the richer outcrop zone. The general result of a study of the map and table is to show that, while the content of the ore decreases slightly in depth, this decrease is not alarming, and that the prospects as regards the gold content of the Rand in depth are distinctly encouraging. There are one or two details in connection with the plan and table that are worthy of notice. In the first place, Mr. Marriott holds the view that the outcrop zone necessarily has the highest gold content, as it includes the results of secondary enrichment forming the residue of denudation, which must have amounted to some thousands of feet. Some geologists may differ from him as to the cause of this enrichment, but owing to the proved continuance of the deposit to so great a depth these surface considerations, whatever the theory, have little bearing on conditions to be expected at still greater depths. Second, the deepest working on the Rand at present is shown to be in the Village Deep, where the main shaft is down 5,350 ft. vertically below outcrop, or 9,800 ft. measured on the dip. The third point relates to the disposition of the richer ore in the reef. From an inspection of the coloured plan it is clear that the richer ore occurs in continuous shoots, which have the orientation, N.W. to S.E., characteristic of the profitable shoots in the Far East Rand. Mr. Marriott said in his address that this plan has repeatedly helped him in showing the best spots for close development. We may suitably conclude this brief reference by saying that the plan will form one of the classics of mining. Lucky is he who has a copy of it.

The Gold Output.

It is always difficult to make an estimate of the yearly output of gold throughout the world. Three quarters of the total can be fairly accurately stated, for most of the governments publish statistical returns within a month or so of the end of each year. Other governments are dilatory, and issue figures eighteen months to two years late. Yet others never issue any at all, sometimes through inability or indifference, and sometimes for sound reasons. Moreover the official figures promptly issued are not always accurate. For instance, returns may be duplicated by the mine and the custom smelter; figures may be based on the realized value and not on the actual ounces; in other cases the reports deal with export or delivery at the mint and not with the actual output of the mines. It will therefore usually be found that in comparative tables the figures for any particular year are altered and corrected as more complete information arrives. This fact should be remembered when historical searches are being made.

The table which we give herewith shows that the total output of the British Empire during 1917 was £56,454,410 and of the whole world £88,693,860, as compared with £59,975,800 and £95,672,780 in 1917. By reference to the figures it will be seen that, on the African continent, the outputs of the Transvaal, Rhodesia, and West Africa have shown declines. In Australia the drop is more marked, especially in Victoria, Queensland, and New South Wales. The outputs in New Zealand and India show only slight falls. The Canadian figures for 1917 are much lower than those of 1916. The strike at the coal mines and the consequent stoppage at the smelters accounts for

Gold Production of the World during 1916 and 1917.

Production of British Empire.

	1916	1917
	£	£
Africa:		
Transvaal	39,484,934	38,323,921
Rhodesia	3,895,311	3,495,391
West Africa	1,615,306	1,529,977
Egypt & Sudan	70,000	66,000
Total Africa	45,065,550	43,415,290
Australasia:		
West Australia	4,508,532	4,136,600
Victoria	1,090,194	846,540
Queensland	937,288	744,500
New South Wales	459,370	349,000
South Australia	24,360	32,482
(including Northern Territories)	6,500	
Tasmania	75,552	59,588
New Zealand	1,199,212	1,189,200
Total Australasia	8,301,000	7,357,910
India	2,299,570	2,214,160
Canada:		
British Columbia	934,675	570,152
Ontario	2,080,504	1,830,841
Yukon	896,941	753,435
Manitoba	} 37,560	1,871
Quebec		6,402
Nova Scotia		9,348
Total Canada	3,949,680	3,172,050
Federated Malay States	70,000	65,000
British Borneo	140,000	80,000
British Guiana	150,000	150,000
Total British Empire	59,975,800	56,454,410

Rest of the World.

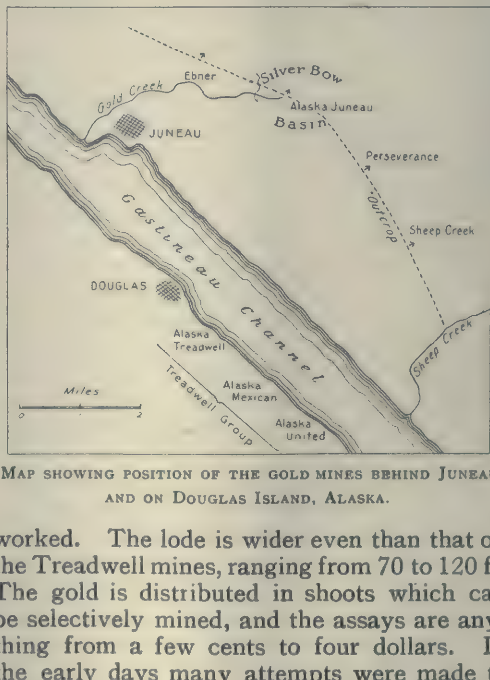
	1916	1917
United States:		
Main Portion	15,424,320	14,156,580
Alaska	3,311,100	2,893,110
Philippines	311,560	312,760
Total United States	19,046,980	17,362,450
Mexico	1,750,000	2,000,000
Central America	700,000	500,000
South America	2,800,000	3,000,000
Russia & Siberia	6,500,000	4,500,000
Europe other than Russia	400,000	300,000
Japan and Korea	2,500,000	3,000,000
China	750,000	750,000
Madagascar	170,000	150,000
Congo	330,000	377,000
Dutch East Indies	650,000	500,000
Total Rest of World	35,596,980	32,239,450
Total for whole World	95,672,780	88,693,860

the decline in British Columbia; labour scarcity and high costs have interfered with operations in Ontario; the fall in the Yukon figures is due to the exhaustion of placer ground. It is interesting to note that Manitoba puts in a first appearance as a gold producer. It will be seen that the United States figures continue to recede; in particular Colorado and Nevada are falling off; detailed figures by states were given in our February issue. The Mexican figures are estimated from representative returns, and the increase during 1917 is due to the enforced reopening of many mines. The Russian output was showing a shrinkage before the debacle, owing to scarcity of labour. The Japanese are increasing their output both at gold mines and in by-products at the smelters. There are also other countries where small amounts of gold are produced, for instance, New Guinea and Nigeria, but complete figures are not available at present; Broken Hill Block 10 is working the Misima mines in New Guinea, and the Champion Tin Fields operates a gold property in Nigeria.

In looking to the future, four factors rule the situation about equally. Scarcity of labour and plant stands in the way of expansion, and indeed is leading to a curtailment of operations. The high cost of labour and material is advancing the minimum limit of payability. The exhaustion of the known deposits and the absence of new discoveries are bound to reduce the output substantially. The political disturbances in Siberia and elsewhere are seriously curtailing the opportunities for mining. When peace is restored and better methods of government are introduced the outputs of Siberia and Mexico may be increased. There is hope for the expansion of the gold-mining industry in several parts of South America. Central Africa also is a territory of great promise, though details of present performance are necessarily unpublished.

Bad Luck in Alaska.

The great gold-mining centre behind Juneau and on Douglas Island, Alaska, is under a cloud at present. Old mines with a brilliant record and new mines with even greater promise have lost their glamour, and are struggling for existence against difficulties that appear almost unsurmountable. The Alaska Treadwell group, all but the Ready Bullion mine, after paying handsome profits for many years on two-dollar ore, was swamped a year ago by the sea penetrating the partly caved hanging-wall, and both the reserves in the upper levels and the ore in the bottom of the mine were lost. Unless some part of the ore can be attacked by a long cross-cut from the Ready Bullion workings, there is no hope for the flooded property, and the last chapter will have been written on an enterprise that brought profit to the capitalist and credit to the engineers in charge. As we gave full details of this disaster in our issue of June, 1917, it is not necessary to say more now, and so we pass to a consideration of the present position of the mines on the mainland. These two mines, the Alaska Juneau and Alaska Gastineau, are on the Perseverance lode, the existence of which was known in the seventies before the lode of the Treadwell group was



MAP SHOWING POSITION OF THE GOLD MINES BEHIND JUNEAU AND ON DOUGLAS ISLAND, ALASKA.

worked. The lode is wider even than that on the Treadwell mines, ranging from 70 to 120 ft. The gold is distributed in shoots which can be selectively mined, and the assays are anything from a few cents to four dollars. In the early days many attempts were made to mill the selected portions, but none of these ventures lasted long. In the early nineties, the Gastineau property, then called the Perseverance, was acquired by the late Colonel W. J. Sutherland, for whom Mr. Arthur L. Pearse made an examination and reported favourably. In 1905, Mr. J. H. Clemes examined the property on behalf of John Taylor & Sons, but did not secure sufficient evidence to confirm Mr. Pearse's estimates. Next year Colonel Sutherland raised money elsewhere in London and erected 100 stamps. The average yield was \$1·80 per ton, and the local expenses were about half this, but for various reasons no dividend was ever paid. After the Colonel's death in 1911, control was secured by Hayden, Stone & Co., who commissioned Mr. D. C. Jackling to develop the property on a big scale with a plant having a capacity of 6,000 tons per day. When this firm floated the company, it was estimated that 75,000,000 tons of ore was "definitely indicated," averaging $1·75 per ton, and that the cost would be 75 cents per ton. Mr. Jackling was not an advocate of selective mining, for he saw difficulties in the way of choosing the ground accurately, and moreover the cost of mining by that method would be much higher than that associated with wholesale caving. He also introduced the method of comminution employed at his porphyry copper mines, using rolls instead of stamps, and a similar concentration plant for extracting the auriferous sulphides. Millions of dollars were spent on development and plant, and the flotation of the property was one of the sensations of the time. It was not long, however, before the estimates of gold content were falsified by practice, for the first 1,200,000 tons milled yielded only $1·17 in gold per ton, and an unpleasant collapse of the shares followed. Mr. Jackling was not daunted, but has persevered in an endeavour to find richer sections. He has unfortunately been doomed to disappointment. The latest return to hand, that of January of this year, is the worst on record, for 179,300 tons of ore treated yielded only 70 cents of gold per ton.

During all these years, Mr. F. W. Bradley, consulting engineer and chairman of the Treadwell group, had had his eye on the Perseverance lode, and his experience in mining and milling led him to believe that the ore could be treated at a profit. He accordingly acquired control of the Juneau property to the north, which had been worked on a comparatively small scale for a dozen years, by a company in which Wernher, Beit & Co., Smith & Perkins, and the late Thomas Mein were largely interested. Mr. Bradley undertook to drive an adit 5,700 ft. long, by means of which the ore-body could be more cheaply and continuously mined, in return for a block of shares, and the capital required was supplied by himself, Messrs. J. H. Mackenzie, Mark L. Requa, and Ogden Mills. After the adit had been completed and the deposit examined at this horizon, Mr. Bradley came to the conclusion that he could extract $1·45 in gold per ton at a cost of 80 cents. A pilot mill was erected, and the results of its working showed that the average assay-value of the feed was $1·50, and also that by selection of the ore the average of the feed could be raised to $3·00. Subsequently this mill was employed in sampling the ore-body on a large scale, and after three years' testing, Mr. Bradley announced in 1916 that with a plant having a capacity of 10,000 tons per day it would be possible to treat $1·00 ore at a cost of 50 cents. A mill was designed with a capacity of 8,000 tons per day, intended as the first unit of a larger plant, and this was started in April, 1917. There does not appear to have been unanimity between Mr. Bradley and his two engineer associates, Messrs. Requa and Mackenzie. For one thing, he was averse to the public flotation of the company, preferring to conduct it as a private enterprise, but in this matter he had to give way, and the Alaska Juneau company was introduced to the public in 1915. Later, on his being invalided, the technical control passed for a time to Mr. Requa, who, with Mr. Mackenzie, determined to throw over Mr. Bradley's design for a mill on Treadwell lines and to substitute Bonnot ball-mills for stamps. As already mentioned, this mill started in April, 1917. The results were disheartening and even appalling. The ball-mills, which are of an untried type, failed to work to the estimated capacity, and only treated 1,200 tons per day in May and 3,274 tons in December. During the last four months of 1917, the yield per ton was only 62 cents, and the cost was 70 cents, so that the yield was less than one-half the figure estimated and the cost 40% greater. During February of this year the yield was only 44 cents per ton milled. Strenuous endeavours are now being made to improve the milling practice. Modifications are being made in the system of mining, whereby ore of higher average grade and less barren rock will be extracted, and it is hoped in future to send $1·25 ore to the mill, from which $1·00 in gold can be extracted. With Mr. Bradley now back in control there is encouragement for an improvement. The failure of the Gastineau and Juneau companies to fulfil the prognostications is to be regretted, not only for the usual reasons, but also on account of the adverse influence it will have on future ventures for extracting gold from low-grade ore-bodies. With the world's supplies of richer ores becoming exhausted, we have been looking to replenish our gold resources by the wholesale treatment of big low-grade ore-bodies, just as the disseminated coppers came to the rescue when the supplies of richer copper ores began to show the limits of possibilities. However, the disseminated coppers were failures at first; we may hope that the gold mines behind Junea will similarly recover from their early knock-down blows.

REVIEW OF MINING

Introductory.—We are still in the throes of the great struggle on the Western Front. Germany promptly broke its peace treaty with Russia, and the influence of this action on the Russian population is working in favour of the Allies. In the metal market, the release of 350,000,000 oz. of silver by the United States Government and the fixing of the price at $1·00 per fine ounce have had a steadying effect in silver. The price of tin still soars, and stands at £380 per ton, in spite of the Government control just imposed.

Transvaal.—The figures for the monthly output of gold, coal, and diamonds are now arriving too late for inclusion in our pages, but we give the figures for a number of months past in our statistics page. The March returns for native labour show that the improvement noted last month continues, 183,055 being employed at the gold mines at the end of March, as compared with 181,066 at the end of February, 176,424 at the end of January, 172,740 at the end of December, and 169,083 at the end of November.

Owing to delays in the post, the South African houses have found it advisable to cable summaries of the reports of the various mines for 1917, in advance of the despatch of the complete statements. These summaries are intended rather for the investor than for the technical man, and they do not contain much of the information that we are in the habit of quoting in another part of the Magazine under the heading "Company Reports." We give herewith some of the more interesting points with regard to the financial results, pending the arrival of the full reports.

Rand Mines, Limited, reports a profit for 1917 of £863,682 as compared with £953,181 for 1916, and dividends at the rate of 145% absorbing £772,672, as compared with 150% and £797,248. The amount of £198,199 has been written off reserve account to meet depreciation of shareholdings and investments. These now stand at £3,242,021. The reduction of the distribution reflects the lower profits and dividends of some of the mining companies in this control. For instance, Village Deep paid 16¼% as compared with 18¾%; Geldenhuis Deep paid 20% as compared with 25%; Crown Mines paid 40% as compared with 50%; Ferreira Deep paid 28¾% as compared with 38¾%. On the other hand Modderfontein B paid 85% as compared with 77½%. The rates of distribution at City Deep and New Modderfontein showed no change.

Modderfontein B treated 517,500 tons for a working profit of £709,600, as compared with 543,700 tons and £687,290 in 1916, and paid 85% as dividend as compared with 77½%. The ore reserve on December 31 was estimated at 3,523,810 tons averaging 9·2 dwt. per ton. The ore disclosed during the year was 660,000 tons averaging 10 dwt. The additional plant, which will bring the monthly output from 45,000 to 60,000 tons, will be ready to start in four months.

City Deep treated 744,100 tons for a working profit of £682,019 as compared with 725,700 tons and £715,050 in 1916, and paid dividends amounting to 45%, the same as the year before. The total reserve on December 31 was estimated at 3,326,900 tons averaging 9 dwt. per ton. The assay-value was much the same, but the tonnage was less by 349,200 tons, owing chiefly to certain low-grade blocks being eliminated from the calculation.

At Crown Mines, 2,100,000 tons was treated during 1917 for a working profit of £628,898, as compared with 2,266,000 tons and £773,233 for 1916. The yield, cost, and profit per ton were 25s. 9d., 19s. 4d., and 6s. 5d., as compared with 25s. 6d., 18s. 4d., and 7s. 2d., and the dividend was 40% as compared with 50%. The profitable ore exposed was 1,366,000 tons averaging 7·5 dwt., as compared with 2,743,900 tons averaging 6·1 dwt. Some low-grade blocks had to be eliminated from the estimate of ore reserves, which stood at December 31 at 8,998,000 tons averaging 6·3 dwt., as compared with 11,429,000 tons averaging 5·9 dwt.

The East Rand Proprietary's cabled summary for 1917 states that 1,741,300 tons was milled, yielding 21s. 11d. per ton at a cost of 19s. 9d. per ton. The profit carried to appropriation account was £108,100. The reserve at December 31 is estimated at 2,732,000 tons averaging 6·2 dwt., as compared with 4,800,000 tons averaging 6·3 dwt. the year before. The outlook is gloomy from the point of view of discovering additional ore, and also there will be difficulty in maintaining the rate of output owing to there being fewer working faces.

It is stated that the Vlakfontein property belonging to the Lace Proprietary Mines Ltd. is to be developed. This farm is in the Far East Rand, and lies between Rietfontein and Grootfontein, the former being now leased to Springs Mines and the Anglo-American Corporation, and the latter belonging to the Consolidated Gold Fields and containing the property recently acquired by the Sub-Nigel. The bore-holes that were sunk a dozen years ago gave evidence of the existence of auriferous banket, but the assays were not considered good enough at the time. With our greater present knowledge of the occurrence of gold in the Far East Rand, the company is now fully justified in embarking on a comprehensive scheme of development.

As recorded last month the Rietfontein West property, recently acquired by the Anglo-American Corporation of South Africa, is to be developed from the workings of Springs Mines during the period that the shafts are being sunk. In this way a great deal of time will be saved in proving the deposit and in driving the haulage-ways and levels. In return for the granting of these facilities, the Anglo-American Corporation grants to shareholders in Springs Mines the right, extending for two years from the date of the registration of the new company or for one year after the declaration of peace, whichever date may be the later, to purchase 150,000 £1 shares in the new company at 22s. 6d. each. Option certificates will be distributed on the basis of one option for every ten Springs Mines shares held. The Springs Mines company has also arranged to buy 120,000 shares at par in the new company, using accumulated profits for the purpose, and will distribute these among shareholders as a bonus.

The monthly reports issued by Randfontein Central give rise to much anxiety. The tonnage has decreased from 167,000 in January to 149,000 in February, and 129,000 in March. There is not much decline in the yield of gold per ton, the respective figures being 24s., 23s. 8d., and 23s. 5d., but the smaller tonnage has sent up the cost per ton, the figures being 19s. 10d., 21s., and 25s. The flooding of the workings also added to the cost. The consequence is that during March the mine was worked at a loss of £9,841, or 1s. 7d. per ton.

A Government Committee has been sitting with the object of finding some way of helping the low-grade mines of the Rand that are threatened with disaster if working costs mount any higher, but apparently the Committee has little sympathy and the position is not relieved. Representatives of the industry have asked the Government to bear the cost of pumping and keeping the workings in repair at some of the low-grade mines. If these mines were closed, the labour force could be sent to richer mines, which have the plant ready for expansion of the output. It was argued that the consequent increase of profit from the richer mines would bring additional fiscal revenue to the Government as an offset to the cost of keeping the closed mines in good condition. The Committee, however, thought the rich mines could help the poor mines direct without the intervention of the Government. It is difficult to see at present a satisfactory solution of the case of the low-grade mine.

The Mining Leases Bill has passed through the Union House of Assembly. The Bill is the natural sequence to the decision last year to abandon the idea of state mining and to grant leases. It establishes a Mining Leases Board and fixes the maximum and minimum scales for the Government share in the profits. A larger mynpacht is to be granted, but on the other hand the mynpacht has to be taken in one piece, not divided according to the advantageous neighbourhood of several adjoining properties. We shall revert to the new Act when the text as amended arrives.

Rhodesia.—The output of gold in Rhodesia during March was worth £230,023, as compared with £232,023 during February and £300,183 in March, 1917. The return from Cam & Motor showed gold produced £14,051 and working cost £17,060. The low return was due to five days' idleness owing to renewal of part of the metallurgical plant, and also to excessive water in the mine during the early days of the month. With so many mines ceasing operations on account of the war it is of interest to record the re-opening of an old property, the Bush Tick. Here it is intended to adopt selective mining and to extract only the richer parts of the lode.

The output of lead at Rhodesia Broken Hill during April was 1,044 tons, as compared with 666 tons in March and 812 tons in February. The first furnace started last June and the second in October. The estimated capacity when everything was in order was 1,000 tons monthly.

The Globe & Phœnix company is still publishing scanty yearly reports, for the reason that the law-suit brought by the Amalgamated Properties of Rhodesia with regard to the ownership of the John Bull claims has not yet been cleared out of the way. An appeal to the House of Lords was lodged in December last, and will be heard at an early date. The report for 1917 mentions that the output of gold was worth £403,370, and that the working profit was £288,012, of which £20,424 was paid as tax and £15,868 was written off for depreciation. The shareholders received £266,666, the rate being 133⅓% less income tax. As we mentioned last month, the reserve was estimated on December 31 at 184,053 tons averaging 28·9 dwt. gold per ton, as compared with 173,981 tons averaging 29·5 dwt. the year before. The report states that the new vertical shaft is in commission and that the new copper property is being developed under the direction of Mr. D. P. McDonald, the development ore paying a large part of the expenses.

The long expected case of the ownership of unalienated lands in Southern Rhodesia was argued before the Judicial Committee of the Privy Council last month and judgment was reserved. It had always been supposed that the concessions granted by the Matabele King, Lobengula, vested the rights to these lands in the British South Africa Company. When, however, the administrative functions were taken out of the hands of the company on the lapse of the original charter, and the company became merely a trading concern, the question of the ownership of the lands arose. The Crown argues that the land is public property by virtue of its having exercised a protectorate over the country. The Legislative Council holds that the company is only administrator and not owner. The natives of Southern Rhodesia claim that the ownership was never acquired either by the Crown or by the company, and that it remains with them.

West Africa.—The output of gold during March was worth £112,605, as compared with £112,865 in February and £107,863 in January. The output at the Ashanti mine is gradually becoming normal, the effect of the fall of soft hanging wall a few months ago thus being overcome. The Offin River company reports that operations were suspended at the dredges in January. The staff is so depleted that it will only be possible to work one dredge in future. This will be floated to a new centre shortly and operations resumed.

In another part of this issue we give particulars of the gold output of the world, and mention that Nigeria is a country producing gold on a small scale, though actual figures are not to hand. One producer is the Champion Tin Fields, which reports a yield worth £5,813 during the year ended June 30, 1917.

Australasia.—The agreement between the British and Australian Governments relating to the disposal of zinc metal and concentrate has been extended, and the shares of the Broken Hill companies have advanced in value. The new contract controls the whole of the Australian output for the period of the war and for ten years thereafter.

The output of concentrate and ore at Broken Hill during 1917 is reported as follows: Silver-lead concentrate 218,518 tons, zinc concentrate 278,544 tons, silver-lead carbonate ore 28,890 tons. In 1916 the figures were 212,397 tons, 206,196 tons, and 35,409 tons; in 1915 they were 221,696 tons, 183,094 tons, and 51,325 tons.

The Hampden Cloncurry Copper Mines, Ltd., has purchased a property at Mount McNamara, situated 16 miles from Cloncurry and 7 miles from Longara station on the Cloncurry Selwyn railway. During the time covered by the option, from 600 to 700 ft. was sunk and driven, and promising ore averaging 12 to 17% copper was exposed.

A rush took place a month or two ago to Kin Kin, about 13 miles east by south of Gympie, Queensland, where prospectors reported gold ore averaging 10 oz. per ton. The venture, however, proved a fiasco and the boom was short-lived, for even the original discoverer found little more than a few patches of gold. The district contains granite and other igneous intrusions in contact with slates, and gold has been found and properties worked on previous occasions, though without any notable success.

The appeal of Aron Hirsch und Sohn from the Australian judgment in favour of the Zinc Corporation has been dismissed by the Judicial Committee of the Privy Council. The German metal firm will therefore have to pay forthwith the sum of £80,000 odd for zinc concentrate despatched before the outbreak of war.

Malaya.—It is announced that the railway connecting Siam and the Malay Peninsula is completed and will be opened for traffic immediately. The line will make through connection between Bangkok and Singapore. Owing to the difficulty of securing rolling stock, it is not likely that the traffic will be extensive until after the war.

India.—Development in depth in Bullen's section at the Ooregum mine is hindered by the increasingly broken nature of the ground. In the lowest level in Oakley's section, the 57th, the lode for 166 ft. has averaged 33 in. in width and 21 dwt. per ton, and the prospects are accordingly more cheerful. It is hoped that, with this new supply of richer ore, the reduction in the yield per ton which has been foreshadowed by the superintendent may be obviated. At the Nundydroog, the chief developments have been on the ore-body in the Oriental and Kennedy's sections. This ore-body is not so long or rich on the 3,650 ft. level as on the two levels above. In a winze below the 3,800 ft. level, the ore is 28 in. wide and averages 48 dwt. per ton. This mine has been suffering lately from a shortage of labour.

Developments in depth at the Hutti (Nizam's) mine continue to be disappointing. The only discovery of note has been in a winze below the 3,200 ft. level, but the grade of ore did not continue downward and in the 3,300 ft. level the assay-value was low. Further developments on these two levels are being pushed. During 1917 the yield of gold was £50,701, a fall of £22,050 as compared with 1916.

Egypt and Sudan. — Developments at the Barramia mine have been poor lately, no more of the characteristic rich pockets having been found, so underground operations were suspended at the end of 1917. It is hoped, however, that when more normal conditions prevail it may be possible to resume exploration. The cyanide plant for treating accumulated sand and slime was started in March. These accumulations amount to 30,000 tons. The funds for building the plant were provided by the issue of £6,000 debentures. At the Om Nabardi mine of the Sudan Gold Field, a plant for treating current and accumulated slime, with a capacity of 1,500 tons per month, will be ready shortly.

United States.—Last month we gave particulars of the United Verde Extension copper mine in Arizona, and of the method of discovery of the bonanza. The company has built a new smelter on a site near the Verde river, about three miles south of Clarkdale. The plant consists of six roasters, two reverberatories, one blast-furnace, and three converters. The reverberatories are 25 ft. wide and 120 ft. long, and are fired with pulverized coal. The blast-furnace is 48 in. by 320 in. in cross-section. The converters are of the Great Falls type, 12 ft. in diameter. The plant is nearing completion and operations may start this month.

The output of aluminium in the United States during 1917 is estimated at 80,000 tons as compared with 62,000 tons in 1916, and 44,000 in 1915.

We have on several occasions recorded the expansion of interests on the part of the Anaconda company. The latest new departure is the production of ferro-manganese. The furnaces are to be erected at Great Falls. Rhodocrosite ore from the company's mines and from other mines in the neighbourhood of Butte will be smelted by electric heat. The contemplated output is 30,000 tons per year.

The ghost of disputed ownership at the potash and borax deposits of the American Trona Corporation has been laid by a decision of the Department of the Interior to the effect that deposits of salts either as crystals or brine come under the classification of minerals and can be located and patented under the Mineral Act. This corporation is controlled by the Consolidated Gold Fields of South Africa, and the potash extraction commenced last year promises an important accession of business.

A society called the American Association of Petroleum Geologists has been formed, and the first meeting was held in February at Oklahoma, where a number of valuable papers were presented.

Mexico.—The Mexico mine, the property at El Oro which has done so handsomely for its shareholders, is now developing no more ore. Above the 11th level the extent of the ore-body is fully proved, and nothing of value is being found below. The mine is, however, far from its end, for it still contains 457,100 tons of ore averaging \$11·89 gold and 8 oz. silver per ton, sufficient to keep the mill going for six years. The directors have decided that the manager, Mr. Fergus L. Allan, shall test other properties, and have allocated £100,000 out of profits to form the capital of a company to be formed for the purpose.

Russia. — A year ago we recorded the arrangement for the purchase from the Lena Goldfields of a controlling block of shares in the Lenskoie company on the part of Mr. G. Benenson and his Russian friends. The payment for these shares was to be made in instalments. The present conditions in Russia have made it practically impossible to complete the purchase, so by agreement the period for payment has been extended.

Spain and Portugal.—From the reports of Spanish copper and sulphur companies, abstracts of which appear in our pages, it will be seen that the outputs and shipments have been fairly well maintained. On the other hand Mason & Barry, operating the San Domingos mine over the border in Portugal, have been badly hit by the scarcity of shipping. This position is explained by the fact that steamers of small size are required for access up the Guadiana river to Pomaron, whereas the Spanish companies shipping from Huelva can be served by ships of a greater variety of tonnage. The Tharsis company has relied during the last few years on the Calanas mine, but new ore-bodies have been developed at the Tharsis property recently. The Sierra Bullones ore-body is now fully prepared for the extraction of ore by open-cut, while at the North lode the ore proved entitles the deposit to be called "immense."

WOLFRAM DEPOSITS IN THE ARGENTINE

By RALSTON C. SHARP, Assoc.Inst.M.M.

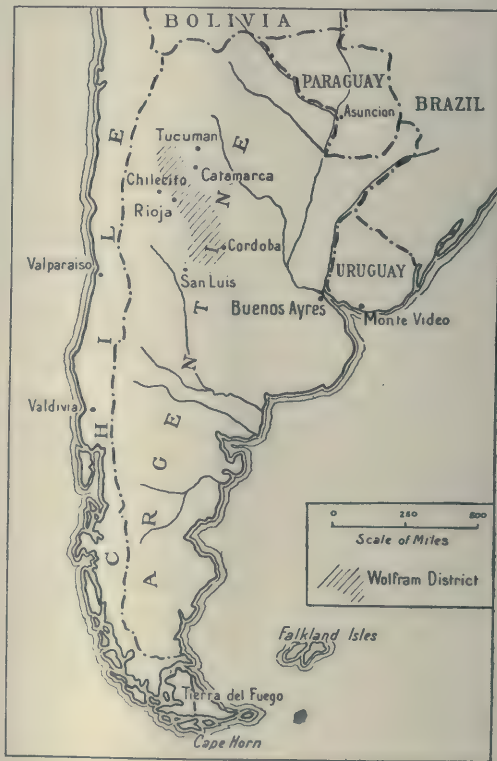
WOLFRAM has been worked in Argentina for more than fifteen years and large supplies have been obtained. In view of the keen demand existing, I went out and inspected the deposits in that country, where further discoveries had lately been made. My observations as to the occurrence of this mineral, the methods employed for its extraction, and the local conditions prevailing there, may be of interest as affording information about a source of supply hitherto controlled by the German government.

Argentina is bounded on the west by the Andes, the geological backbone of the continent. These mountains, gradually sloping to the east, merge into the extensive plains or pampas that characterize the topography of this great agricultural country. About 250 miles east of the Andes a parallel range extends from about latitude 25° S. to about 35° S., and is termed the Pampa Range. It forms isolated peaks, chains, and undulating plateaux.

Wolfram ores are found in this range at an altitude of from two to five thousand feet, in quartz veins and lenses traversing Pre-Cambrian and Paleozoic formations. As a rule the veins strike east and west and dip north. In them the following varieties of tungsten ores are found: wolframite, wolframine, hubnerite, and scheelite. Associated with them in the same veins are: bismuthine, molybdenite, various minerals of copper, tin oxide in very small quantities, and mica. Bismuthine is rarely absent, and on one occasion I found as much as 8% in hand-washed concentrate. Dykes of pegmatite, containing tourmaline in addition to the quartz and felspar, generally strike north and south, and are one of the features of the country, being numerous and of remarkable extent. They have been much prospected by the miners who mistook the large tourmaline crystals for wolframite. But although this last mineral has been found in similar formations in South Dakota, I could not find that it existed in the Argentine pegmatite dykes. On the other hand these dykes are not without their value, for several varieties of muscovite have been discovered and payable sizes extracted.

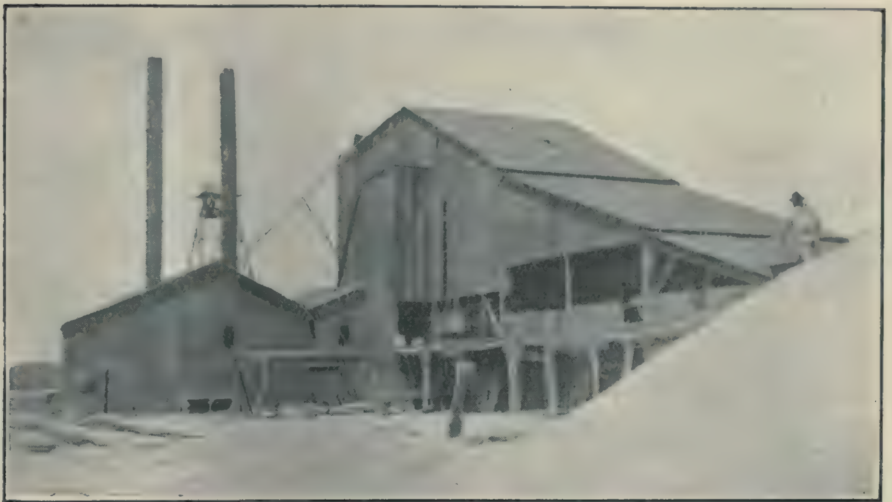
The principal localities in which wolfram was being mined are marked on the accompanying map, and beginning from the north are: Cajon, Gualapaji, Amboti, Incasti, Colorados, and Mazan, all in the province of Catamarca; Guasapampa, Quines, Pisco Yacu, Concoran, Carolina, San Ramon, and El Morro, in the provinces of Cordoba and San Luis. A few details of the above mines may be of interest.

In Colorados, twenty kilometres east of the town of Chilicito, wolfram is found in quartz veins in aplite, with red granite and gneiss on



either side. I believe its occurrence in aplite is unique. The principal vein is about 40 cm. wide and carries 1½% wolfram. Chalcopyrite, bismuthine, and molybdenite are also found, the latter in quantities that would warrant attempts at recovery, but it was being thrown on to the dumps. About twenty men were engaged in mining, but, the rock being hard, the advance is slow with hand drilling. The ore, extracted by adits along the veins, is carried out to the picking floors, hand sorted, and sacked for export. The fines were piled up, no attempt being made to wash them.

In Mazan, about 35 kilometres to the north of the town of La Rioja, a small French con-



WOLFRAM CONCENTRATING MILL AT PISCO-YACU.

cern was at work. The ore was being quarried out of a flat vein about three feet wide, and was the only instance I met with in which both wolfram and tin were being mined together. These two minerals are so coarsely distributed in the vein, the tin in large dark-coloured crystals of cassiterite, that hand picking alone sufficed to raise the assay to 65%.

In Concoran, the only mine of any real importance in this country, wolfram has been worked for a number of years by a German company controlled by Krupps. The vein, in a granite and gneiss contact, is about a metre wide, and the outcrop can be traced for over two kilometres. The ore appeared to have been exhausted down to the level of the main adit, from which a shaft has been sunk one hundred metres, opening up new ground. The vein, which strikes east and west, is practically vertical, and at the level of the adit a succession of step-faults necessitates cross-cutting toward the north at regular intervals. Air drills of American make are extensively used. There is no hand selection of the ore, the entire output being treated in bulk by a 150 ton concentrating plant. About forty tons of concentrate is produced per month, the greater part by jigging, containing from 62 to 65% WO_3, asso-

TRANSPORTING RICH FINES TO THE MILL IN FORD CARS.

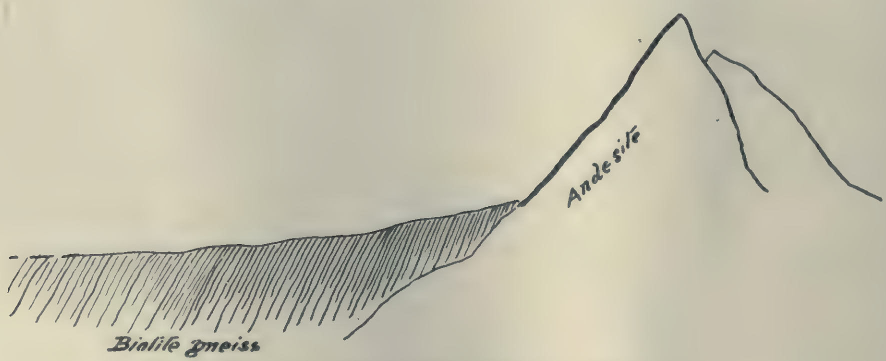
ciated with copper and with bismuth. There is considerable loss of fine wolfram in the tailing, of which large dumps exist.

In Pisco-Yacu an English company is working a property the surface rights of which embrace eight square miles. Outcrops of several veins in gneiss and in granite can be traced for hundreds of metres, but mine development was in a preliminary stage. A shaft had been sunk to a depth of only sixty feet, so that ore supplies were dependent on trench work in the oxidized zone. I reorganized their concentrating mill, which consists of breaker, rolls, jigs, Wilfley tables, Frue vanners, and round buddles. The concentrate contained as much as 69½% WO_3, associated with bismuth, copper, and molybdenite. An air compressor and Holman's drills completed the plant.

The Morro mine, situated on the western flanks of the mountain of that name, was being worked by an American syndicate. A network of veins in biotite gneiss with well defined walls strike across the cleavage planes. They lie flat, dipping at about 35° to the north and resemble the lenticular deposits in Portugal. Bunches of exceedingly rich ore were being found on the surface, especially at points where the veins intersected, and an adit was being driven to cut them in depth.

I replaced the hand drilling for a small compressed-air plant, and erected a suitable little concentrating plant, an easy operation, for the ore in this mine was exceedingly docile and readily dressed to 70% WO_3 without calcining. Alluvial wolfram was also being dug up in the dry creeks on the property, and the pieces, blocks, and crystals, quite waterworn and rounded, weighed up to several pounds. They were very pure, and when broken split along the cleavage exhibiting the brilliant lustre of wolfram.

General Section of Ground at Colorados Mine.



Vertical Section of Morro Formation.

In the San Ramon claim there were a number of quartz veins in mica-schist. They followed the bedding planes and gave one the impression of being entirely superficial. A prospecting shaft was being sunk, but most of the ore was extracted on tribute, each miner being supplied with a small amount of dynamite which he employed wherever he found a prospect of obtaining a rich pocket. The ore in this locality gave the highest percentage of tungstic acid, due to the large proportion of scheelite. A crystal of scheelite from this mine, in the form of a square pyramid two inches high, can be seen in the South Kensington museum. The concentration was effected by women, who are expert with the pan, but the white scheelite sand was lost and could be seen to settle in the bed of the creek.

Speaking generally of the Argentine deposits, the veins appear to contain from ½% to 1½% of wolfram in unevenly distributed crystals, lumps, and slabs weighing up to fifty kilogrammes. Consequently a large proportion of barren quartz has to be worked over, and in many instances the small miner, lacking capital, becomes discouraged and prematurely abandons his claim. An interesting case of this occurred with the German company in its early stages when it leased the mine to one of the native foremen, who shortly afterward had the good fortune to run into a mass of ten tons of wolfram. The company re-started work, and this mine, thoroughly equipped with a modern plant, continues to produce some forty tons of wolfram concentrate per month. This is the only mine in the whole country where wolfram has been systematically worked and proved in depth. Otherwise mining methods are of the crudest, the ore being simply followed down by small inclined shafts. No stoping is attempted, although good props can be obtained, the surrounding country being well wooded. Double handed drilling is the custom, and miners, generally Spaniards and Italians, are paid from 4s. 6d. to 6s. per day. The ore when broken is brought to surface and hand sorted, while the fines are crushed under hand hammers and washed in pansor in sluices. Transport to railhead is carried out by native carts, the cost being only a small item.

Mining claims measure 300 by 250 metres, and the titles are secure if taken up with due regard to the laws of the country and to the customs of the people; otherwise opportunities for litigation are afforded as is the case in any country. Wolfram concentrate, from 65% WO_3 upward, found a ready market in Buenos Aires. The price, owing to the competition of the American munition contractors at the time of my visit, fluctuated from £200 to £630 per ton.

Although the country possesses some 25,000 kilometres of good railway and many roads suitable for motoring, a certain amount of rough riding is unavoidable and a saddle and camp bed are essentials to one's kit. The climate of Argentina is exceedingly dry and healthy, but owing to the prevalence of dust storms in certain seasons of the year, prospecting becomes difficult and unpleasant.

I continued my journey to the north of the province of Catamarca and up the great Aconquijo mountains, where although no wolfram had been discovered, there were interesting deposits of other minerals worth investigating, but good knowledge of the country and its people are indispensable.

WOLFRAM DRESSING FLOORS AT PISCO-YACU: WILFLEYS, FRUE VANNERS, AND ROUND BUDDLES

PROBLEMS OF MINING ON THE RAND

By HUGH F. MARRIOTT, A.R.S.M., M.Inst.M.M., M.Inst.C.E.

We give herewith excerpts from Mr. Marriott's Presidential Address delivered at the meeting of the Institution of Mining and Metallurgy held on April 11.

It may be said of metallurgy that success depends upon invention and improvement of processes, while in mining, success mainly depends upon past experience. You cannot learn mining from a book. It has occurred to me that the best use to which I could put this occasion would be to follow through some of those points in the history of the Rand with which I have been more closely connected during my professional life, that do not appear in text-books or in company records, in the hope that they will be interesting to those who know them, and will also help to direct the action of those who are now only commencing a professional life.

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Following on the results of the prospecting trenches and mining operations from the outcrop, the most progressive method of the early days was to sink bore-holes to cut the reef at comparatively shallow depths. The first of these was at the Village Main Reef, where in 1890 the South Reef was intersected at a vertical depth of 517 ft. It is interesting to observe that while in those days there was a doubt about the existence of the ore deposit even at this short distance from the outcrop, to-day it is not considered an undue risk to invest a million and a half in equipping a property in which the reef lies at a depth of 5,000 ft., and the major portion of the expenditure has to be undertaken before the reef is cut. The second bore-hole was on the Rand Deep Level ground, and was the first proof of the continuation of the ore below the boundary of the Crown Reef. This was sunk in 1892, and cut the South Reef at 823 ft. Intense interest was taken by the community in this bore-hole, and it was on the results therefrom that the ground immediately to the dip of the working outcrop properties was recognized as having a speculative value.

These early bore-holes had a twofold object. The first was to prove the continued existence of the ore-bodies, for in those days, however assured the scientist might have been of the continuity of the deposition, it had to be demonstrated by results to the world at large if the required confidence in the stability of the fields was to be established. The second was to obtain as accurate as possible cross-sections of the reef formation and to furnish material for assays on which to base estimates of the gold contents of the reef passed through. In the first requirement the early bore-holes were extraordinarily successful, and as the evidence accumulated it became possible for a skilled observer to determine, from the results brought up, the distance at which the Main Reef Series would be encountered to within a few feet. As an indication of the value of the reef the results were not so decisive, but it must not be too readily assumed on the records of past work that no weight can be given to results obtained by this method. On the Central Rand, where the reef formation is compact and lies in hard country, the assay results from bore-holes have in several instances been since proved to be very nearly the average of the reef they intersected; but this again must have been very largely chance, as there are often wide differences between closely spaced mine samples. No miner would attempt to value a block of ore reserves on a single sample.

In the Eastern Rand, owing to the friable nature of the foot-wall of the reef, which portion is also the main gold carrier, this was often penetrated without previous warning owing to the absence of reliable upper indicators as found in the Central Rand, and as the core was being cut, the hard quartz pebbles often ground up the soft foot-wall shales and dispersed all the fine gold contents, barely leaving a trace in the core-barrel for the assayer. In the Far East Rand, as in many other cases on different classes of ore, full success has been deferred owing to too close an adherence to an assumption of a normal position for the valuable contents. At the present day it is possible to divert bore-holes at some distance above the reef, and to take another section. The exact location of the reef is then known, and the second sample can be carefully drilled. Cores of much larger diameter are now obtainable in this formation by shot-drilling, thus rendering it possible to obtain a more coherent core. In general it may be said of the returns of values afforded by bore-holes that, provided the formation is there, a poor result is no criterion that profitable contents do not exist in the locality. On the other hand, if a rich result is obtained it is extremely improbable that the sample of ore secured haphazard as one solitary representative of a large area should happen upon an abnormally high-grade patch. It is much more probable that the value disclosed will be found to be repeated many times over in the vicinity.

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How great has been the revolution in mining practice is shown by the fact that before the principle of centralizing the underground transport was adopted, the average number of tons hoisted per shaft per day was 400 tons, whereas now the shafts deal readily with 4,000 tons in the same number of hours per day, or ten times the former amount. The innovation was not evolved from within by gradual changes. The time-honoured method of calling for ore at each and every level of the mine as the ore-bins were filled was too firmly established. The change was effected through the appreciation of the fact that the two great branches of mining, coal and metal, were not so far apart as custom had hitherto decreed, and that each had much to learn from the other. The introduction of coal-mining experience to the Rand and the completion of the first example of colliery practice in hoisting from one central loading station was sufficient to demonstrate the superior efficiency gained thereby, and the system is now the orthodox method of lay-out of a new property.

One point in connection with the further development of the centralizing system remains to be solved, and is now being tackled in various ways. I refer to the position which arises in the case of a vertical shaft fully equipped which is already dealing with all the ore tributary to it, either from above the horizon of the shaft bottom or hoisted to it by means of subsidiary inclines. There are three methods. First, to deepen the main shaft from the surface, or, if it has already reached its economic limit, to sink a vertical shaft just alongside, so that the ore hoisted from greater depths can be transferred directly from one to the other by trucks or through ore-bins. This will necessitate longer cross-cuts at each succeeding level, and does not assist in providing reef exposures ahead of the subsidiary mining operations. The second method may be taken to be the sinking of a main incline shaft under the reef from the bottom of the vertical shaft, the ore being transferred in one operation as above. This has the advantage that evidence is obtainable of the value of the deposit as the work proceeds, and the minimum amount of cross-cutting is required. The chief drawback is the smaller output obtained from each hoisting way, thus possibly requiring two inclines to feed the main vertical shaft. There is also the risk that the inclines may be affected by movements of ground at a later stage.

The third method has only recently entered the arena, and consists of a cross-cut from the bottom of the main vertical shaft in the direction of the dip and a sub-vertical shaft sunk from this cross-cut in a position suitable to control all the lower ore included in the estimates of future working. This system of layout is in the first instance subject to the same criticism as the first method, in that it does not offer facilities for ascertaining the value of the deposit until the work is all completed. But when once the reef is reached, and the subsidiary inclines have also been sunk to the horizon of the bottom of the sub-vertical, it may be found that development can proceed more quickly by this than by any other method. The chief drawback to the system is that the ore is subject to one more transfer than by either of the other two lay-outs, and this, if it does not restrict the output, must cause a permanent increase in costs of hoisting.

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Another problem has arisen in recent years for dealing with which the circular shaft is perferable. I refer to the passage of shafts through watery strata. There have been cases of excessive influx of water in the course of sinking shafts in the quartzites of the Witwatersrand Series. These have been met by the installation of powerful pumps, and notable records of sinking have been done under trying conditions. To-day the conditions on the extensions of the Rand are different, and the shafts in their upper portion have to pass through limestone formation in which there exist fissures connected with underground reservoirs which may produce water in overwhelming quantity. This problem is now well on the way to being solved by the introduction and successful application of the François cementation process on the fields. After an investigation of the successful application of this method of shutting off water from workings in this country, and the results of sealing up of the high-pressure water zone on the East Rand, it is not too much to say that it may be relied on to deal expeditiously with any water difficulty that may be met with in shaft-sinking in the future, provided always that it is properly applied.

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Any system of mechanical transport when working considerably under its rated capacity is uneconomical. The alternative methods of carriage of ore to the surface have not yet had that amount of consideration paid to them which will have to be done when the deposits of ore to be worked are more restricted and more difficult of access, and the profit available from each individual section or block in a mine is more closely calculated. I refer to the question of skips and cages. The skip can more conveniently take the larger tonnage per trip; it can be rapidly loaded and discharged with little extra labour requirements. On the other hand, it is fed from ore-bins which must be of large capacity to meet the needs of the mine. They are expensive to construct and are only useful for the particular section immediately above them. All the different classes of ore that are dumped into them are mixed together and go to the mill as one product. Too often no separate arrangements are made for the disposal of the waste rock that is produced in mining work off the reef, and this also is dumped into the ore-bin, and then has to pass through the treatment plant with the valuable material, thereby adding to the cost, occupying valuable space that might be used in earning profit, using up labour and skilled attention in eliminating it at the successive stages of treatment, and sometimes rendering the actual process of extraction more difficult.

As against the mixed ore supplies from the mine ore-bins, cage hoisting includes some distinct advantages. Ore from any one stope or section of the mine, or even from any one portion of the reef in the stope if mined separately, can be labelled and transported to the surface, passed through the crushers, and carried on to a separate section of the mill where the actual contents can be closely gauged by sampling the issuing pulp. In older practice the actual amalgam from any one section of the ore-body thus treated could be obtained in the mill, but with the more recent methods of placing the plates in a separate building this is no longer possible. Another advantage is the disposal of the waste as the trucks containing this would be diverted to the waste dump, and at a minimum of expense. This alternative involves the capital cost of a larger number of trucks which thus act as storage capacity in place of the bins. It also involves the enlargement of the mine workings in the vicinity of the shaft so that there is sufficient truck accommodation to ensure continuous hoisting as required. Cages have also the advantage that men and materials are more easily conveyed in them than in skips.

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Methods of stoping are now often closely connected with sand-filling and waste and reef packing, particularly so in the Central Rand, where, so far as the upper portion of the mining area is concerned, the withdrawal of support due to the progressive extraction of ore has been followed by an equally progressive settlement of the superincumbent strata, which sometimes comes into action with detrimental effect on the mine workings. To meet this situation as it developed, sand-filling was introduced in 1908. Previous to this date some of the older mines close to Johannesburg had been showing signs of movement, and it became evident that preparation was necessary to meet this tendency, which was bound to increase in intensity as mining progressed. The coalfields of Silesia formed a good object lesson in the support of overlying ground, and, after the methods employed there had been studied, a similar system was introduced on several of the mines on the Rand. This consisted briefly of the hydraulic transport of sand from the surface down to the stopes through pipes, returning the water by pumps specially installed for the purpose.

Filtration difficulties arose on the Rand which had not been experienced in Silesia. The tailings which are employed for the purpose are composed of extraordinarily hard and sharp quartz grains, and the pipes through which they were lowered in the shafts were cut through in a very short time. Various linings were tried at the points most affected, and progress was being made on these lines which bid fair to overcome the difficulty. Confidence in the efficacy of the sand-filling process had, however, in the meantime become more established, and the more stable method of sinking bore-holes of several inches diameter for lowering the sand was being undertaken. It was feared at first that choking might take place, causing long delays, but this was found not to be the case, and after more experience was gained it was found possible to reduce the percentage of water in the mixture largely below the proportions which had been adopted at the commencement from the Silesian practice. This lessens the quantity of water to be returned, and thus considerably reduces the main item of cost. Bore-holes have now been sunk on several of the mines, the deepest being at the City Deep, where a bore-hole of 7 in. diam. was sunk to a depth of 2,000 ft. by means of the shot-drilling process.

It has been found that, after the earth pressure comes on the filled areas, the sand is compressed to a greater degree than had been previously estimated for from Silesian results. It is not yet clear whether this is due to the greater pressure exerted, to the difference in the filling material, or to a variation in the method of hydraulic settlement. The effect is that the overlaying strata are not immediately supported in their original position, but break away to some extent, thus permitting a certain amount of movement which is subsequently arrested.

Waste packs are largely used as supports, and their construction has been highly developed on scientific lines. They are, however, subject to a much greater degree of compression than the water-borne sand, and consequently allow of subsequent earth movements of greater intensity. For purely local purposes the control of the pressure by means of waste packs or broken ore has been found effective, and indeed has largely assisted stoping operations by loosening the ore in the faces, but from the more general point of view the policy should be to support the whole mass of the ground over the reef to the greatest extent possible in order to protect the deeper mines from the undue pressure which otherwise might be caused by subsidence in the upper areas.

It is found that the areas of disturbance caused by mining operations are largely localized by the great dykes which traverse the reef-bearing strata in all directions. The existence of these breaks, together with the modifications being made in mining practice to suit the changing conditions, should form a sufficient safeguard against any but purely local breakaways.

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From 1902 to the present date the averages of yield and cost for the whole Rand are available, and they are as follows:

TONS MILLED, YIELD, COSTS, AND PROFIT OF WITWATERSRAND MINES FROM 1902 TO 1916.

	Total tons milled.	Yield. s.	d.	Costs. s.	d.	Profit. s.	d.
1902	3,416,813	42	0	25	9	16	6
1903	6,105,016	39	8	24	9	14	11
1904	8,058,295	38	6	24	4	14	2
1905	11,160,422	35	10	23	6	12	6
1906	13,571,554	34	6	22	2	12	6
1907	15,523,229	33	11	20	10	13	3
1908	18,196,589	31	5	18	0	13	5
1909	20,543,759	28	11	17	1	11	6
1910	21,432,541	28	6	17	7	10	6
1911	23,888,258	27	11	18	0	9	7
1912	25,486,361	29	0	18	8	10	0
1913	25,628,432	27	9	17	11	9	6
1914	25,701,954	26	6	17	1	9	0
1915	28,314,579	26	3	17	5	8	5
1916	28,525,252	26	8	18	1	8	2

To those unversed in the practice of mining, these figures might, in the bald state in which they are presented, lead them to the conclusion that the ore in the deposit had depreciated in value as the mines were extended. But to those who are acquainted with the inner conditions, the only positive evidence that is afforded by this statement is that, whereas in 1902 the costs were 25s. 9d. per ton milled, only ore above this figure could be worked at a profit, while in 1916 all ore which gave a yield over and above 18s. 1d. came into the same category. The result of the lowering of the cost has been that not only have the fresh developments of lower-grade ore above the reduced pay limit been included in the reserves and sent to the mill in due course, but, as each drop in cost has been attained, ore which was previously standing in the upper levels has been taken into the official calculations of ore reserves, which have thus had two sources tending to lower their average grade. Herein lies one of the weak points of the system of keeping records on the variable basis of "per ton milled." Had the returns of new development always been issued as gold contents per unit of area of ground developed, be it food, yard, metre, fathom, or claim, the successive annual statements of ore reserves would have been comparable and the improvement in methods of mining recognized at its true value, as it would have been shown at once in the reduced costs of working each unit of area.

As the annual yields from the various mines are thus shown to be of no value in arriving at comparisons of the gold contents of the successive zones opened out as the mines are deepened, it has been necessary to construct a new compilation of records practically from the grass roots. Taking into account the many interests concerned, and the varied methods of keeping the earlier records, the inclusion of the whole 55 miles of mines of the Rand would have been infeasible. Further inquiry has also shown this to be unnecessary. The Central Rand was at the commencement the hub of the industry and has remained so until to-day. The mines are connected together in one continuous network, and in the centre of operations the Village Deep main shaft has attained the greatest depth in Rand mining, 5,350 ft. vertically from the surface and 9,800 ft. from the outcrop measured on the dip of the reef. This section of the Rand may be taken for the present purpose as stretching from the west boundary of the Crown Mines to the east boundary of the Nourse, and meas-

Central Witwatersrand, inclusive averages of all Main Reef Leader Development.

Gold Contents in Shillings over the Stoping Widths.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	Distance on dip	Average
																				ft.	
24·00	26·60		55·20	75·13	100·24	69·45	46·89	42·00	27·00	41·55	27·81	57·35	24·24			33·10	33·00	31·10		0 to 1500	44·666
	35·27					66·74				32·12		40·79					32·40				
21·00	21·20	27·13	32·24	48·50	47·13	49·20	49·50	31·27	19 00	26·24	18·24	62·45	22·68	26·81		24·31	20·81	24·24	20·65	1500 to 3000	31·190
	25·39					45·12				21.16			37·31				30·01				
	28·30	26·26	35·82	30·22	46.45	47·17	40·84	36·25	32·22	33·71	44·30	62·33	64·46	37·17		20·12	19·73	24·77		3000 to 4500	37·067
		30·13				40·19				36·74			54·65				21·54				
		20·00	32·66	26·47	31·70	45·30	28·44	28·70	25·16	22·89	44·00	29·64	46·17	44·92	31·10		29·33			4500 to 6000	32·432
		26·33				32·12				30·68			40·25			30·21					
				19·33	31·37	36·00	18·12	32 23	27·60	32·00	48·00	21·50	27·90	36·75	27·00					6000 to 7500	29·817
						27·41				35·87			28·72								
									24·88	26 54	40·40									7500 to 9000	30·606
										30·70											
																			Total	Average	34·192
																Total Average, excluding Outcrop Zone					32·222

Crown Mines. L. Deep Sect. C. Deep Sect. Robinson Deep. City & Sub. Village Deep. Wolhuter. City Deep. Nourse Mines.

← 40,000 ft. →

uring about eight miles along the outcrop.

In order to ascertain the original value of the deposit from which the major portion of the gold has been obtained, I continued the compilation of an assay-value plan which I had the pleasure of exhibiting to some of you in 1914, and is now completed, as far as it is possible to obtain the details, up to the end of 1916. The reason for which this work was originally undertaken was to obtain concrete evidence of the form finally assumed of the various gradations of the gold deposition, and in this it has usefully served it purpose. [We regret that we are unable to reproduce Mr. Marriott's plan owing to its large size. EDITOR.] This plan shows the original gold contents of the Main Reef Leader in the Central Witwatersrand as disclosed by mine development operations. The Main Reef Leader was chosen for the purpose as being the most important and consistent gold carrier, and in offering the advantages of a greatly extended continuous series of exposures for correlation. I have made a close study of this plan for some years, and have from time to time made forecasts of the future prospects of the deeper levels and have compared them later with the actual results of development. I have never yet been able to ascertain from this accumulating evidence any general indication of depreciation of the gold values at depth, and my reading of the plan is that the same conclusion holds good to-day.

In order to demonstrate still more clearly the final results of the great mass of evidence which has been brought together to construct this map, the original assay records have been compiled into blocks of equal area over the whole district. These are set forth in the accompanying table. These block values include all the orginal sampling results, both payable and unpayable, and may therefore be taken as representative of the original gold contents of the deposit. Next, the average results of larger sectional areas have been compiled from these blocks with a view to providing comparative figures at depth over as nearly as possible equal distances along the strike. Then the whole of the recorded results have been averaged to give one figure of value for each horizontal zone. These have been taken for the purpose of convenient calculation in successive depths of 1,500 ft. measured along the dip of these reef. Finally, the horizontal valuations are averaged into one grand total average for the whole of the mines included in the calculation. It will be seen that the outcrop zone records a considerably higher average gold content than the remainder. This was only to be expected, as it includes all the results of secondary enrichment which form the residue from denudation, which must have amounted to some thousands of feet.

In order, therefore, to arrive at a final result for the purpose of comparison, the outcrop zone should be omitted, and if this is done it is seen that the average gold content of the Main Reef Leader of the Central Witwatersrand as disclosed by the original valuation was 32·22s. per mine ton. Now let us see what bearing the individual zone results have on this figure. The uppermost or second zone on the list is 31·19s., and the lowest or sixth zone is 30·60s., a remarkable degree of approximation when it is noted that they are separated by nearly a mile of workings on the dip. In the third zone a remarkable rise of the gold content is noted, which falsified the predictions of many who based their estimates on a descending scale from the mines immediately above, and on the records of gold mines in other localities which have since been proved in no way comparable to the unique occurrence in the Transvaal. The remaining two zones, the fourth and fifth, closely approximate to the general average, and indeed the whole series of averages now set forth show so little variation in gold content for the different horizons that scepticism would be expected were it not that the figures are founded on fact carried to the minutest detail.

If any further corroboration of these decisive results should be needed, it is given by the crushings from the mines included in the calculation since the commencement of gold production. The total results for the central section to the end of 1916 are: Ore treated 93,468,055 tons, yielding gold to the gross value of £170,463,932, or at the average rate of 36s. 6d. per ton milled. When due allowance has been made for sorting, this is seen to be an extraordinarily close confirmation of the original valuation of 34·2s. for the ore as it stood in the mine, a credit to the accuracy of the samplers and to the ingenuity of those who have been charged with the extraction of the gold. A further encouraging feature in support of the prospects of the next deeper zones below those already opened out is the number of points at which high-grade ore has been exposed in the deepest workings. It is thus seen that the gold contents of the deposit have remained remarkably constant throughout the whole life of the Rand, and that the extension of mining operations and the steady growth of the industry are almost entirely attributable to the improved methods of mining and treatment that have been applied as a result of persistent and progressive research.

The problem to-day is: what is the best method of working the deeper levels now being entered upon so that the greatest profit is obtained for the shareholders of the mines concerned. A study of all the evidence I have placed before you lends weight to the opinion, which has already some adherents, that the mode of deposition of the gold in the Central Rand will eventually be found to be not so far removed from that which has been more rapidly proved in the Far Eastern Rand, and that the richer portions of the deposit, while retaining their grade, will be found to be segregated within more closely defined limits. Inquiry should therefore be conducted on lines which will lead to a better knowledge of the characteristics of these channels, lenses, or aggregations of richer ore, and, when located, development should be laid out so that the complete blocking out of ore reserves should only be carried out in those areas which have been shown by the preliminary driving operations to give undoubted profitable results, while the poorer stretches of country should be intersected by the minimum number of levels considered requisite to prove their low-grade character. In other words, the programme should be selective development, where the money spent in opening up new mining ground should be devoted as far as possible to the more likely areas, and the sections which offer but small promise of profit should have sunk in them only sufficient expenditure to prove their limitations. This is no new theory in mining, but it has not yet been applied to the older established mines of the Rand. It will necessarily follow that tonnage outputs will be restricted. This should not be considered a disadvantage, and in some cases the evidence goes to show that the reverse will be the case.

A diagram has been prepared showing the average monthly tonnages and the yields, costs, and profits with the averages per mine for the mines of the Rand for 1917. In character it bears out the deductions made from those similarly constructed for several preceding years. The chief points that stand out are that large tonnage outputs do not necessarily carry with them low working costs, and that high yields give high profits. It follows, therefore, that the chief endeavour should be to raise the yield per ton from each mine as high as is consistent with the average grade of the definitely profitable ore in the reserves, and so modify the organizations and the scale of the treatment plants to suit the output under these conditions.

Here, then, we can leave the future to bring what it may, fully assured that behind the average returns of the mines which represent the practice of to-day there exists a reserve force in the continuance of the high-grade ore at great depths, which may be counted upon to uphold the reputation of the Rand goldfield for a long time to come.

THE EVOLUTION OF ORE DEPOSITS FROM IGNEOUS MAGMAS

By W. H. GOODCHILD, A.R.S.M., M.Inst.M.M., F.G.S.

(Continued from the April issue, page 194).

In this series of articles the Author discusses the principles governing the segregation of ore deposits from rock magmas, introducing several new factors in addition to those already put forward by geologists. He shows how the specific action of certain gases and mineralizers, notably hydrogen and its compounds, together with changes in volume accompanying the later chemical adjustments, explain many obscure problems in the formation of ore deposits.

Introduction to Crystallization Differentiation.

Fractional crystallization accompanied by the sinking of the earlier formed and heavier crystals in the magma, in conjunction with the many collateral effects produced as more or less direct effects of partial crystallization, appear to be by far the most important means whereby large and originally homogeneous masses of magma may become differentiated into a number of products having widely varying chemical compositions and modes of occurrence.

The scope of this discussion of crystallization differentiation is consequently not limited to the mere phenomena of crystallization, but embraces the many collateral effects referred to above. These collateral effects are of immense and far-reaching importance in the general scheme of ore-deposit evolution, since they appear to be largely instrumental in the formation of the mountain ranges, the subsidiary volcanic extrusions, the faults and the fissures, etc., which determine many of the larger features of occurrence of our stores of natural mineral wealth.

It is necessary to treat such a large subject with some degree of thoroughness, although, apart from broad principles, space will not permit of any great amount of detailed elaboration. The following discussion is therefore to be interpreted rather in a broad and general sense than as necessarily being rigidly applicable to the detailed solution of particular or peculiar problems in ore deposition.

Previous attempts to solve the problems of magmatic differentiation have to a very large extent started with the minerals that crystallize from the melts as the basis of the argument. This may be described as the petrological method, in contradistinction to the physico-chemical method, which carries the analysis a step further before attempting to interpret the petrographical data. It will be convenient to subdivide the general discussion of crystallization differentiation into three subsections, as follows: (1) the constituents of the rock-forming minerals and their properties; (2) the constitutions of the rock-forming minerals; (3) fractional crystallization and its effects. The sequence is a natural and logical one, since the second is developed from the first, while with the aid of a proximate knowledge of the construction of the rock-forming minerals it is possible to interpret many of the direct and indirect results of successively crystallizing the different constituents from the melts. The pressures involved in magmatic action are of such enormous magnitudes that in a broad sense the chemistry of rock magmas is very largely concerned with volumes and volume changes.

While the gaseous aspects of magmatic action have been widely, though inadequately, recognized in the past, its volume aspects have to a very large extent been overlooked; consequently in this discussion an unusual amount of stress is laid on volume relationships, and in this respect the following presentation of magmatic differentiation will be found to differ largely from those given in geological textbooks. Intimately connected with some of these volume relationships are the phenomena of isomorphism and what are termed mixed crystals. Isomorphism has been so extensively discussed in the standard treatises on chemistry and petrology, and the part it plays in the construction of complex minerals is so well known, as to make it unnecessary to expand this discussion of the principles of magmatic differentiation by including a mass of material that has been well presented elsewhere.

Similarly the subject of eutectics may be left alone, except to remark that the presence of gases in rock magmas and the "vanishing" character of the mineralizers, hydrogen and its compounds, probably invalidate to no small extent much of the reasoning that has been applied to many of the so-called eutectic mineral associations developed from rock magmas. As far as solid constituents are concerned, the composition of the complex mineral crystals appears to be determined more by the relative concentrations of the constituents in the magma from which the crystals are formed than by eutectic considerations as usually understood. Variations in pressure and gas concentration working in conjunction seem likely to effect the temperature range of crystallization and composition of the separating minerals to a much greater extent than would appear from a consideration of the supposed eutectic proportions of those constituents that finally remain to form the solid minerals.

The Constituents of the Rock-forming Minerals and their Properties.

The principal constituents of igneous rocks are the following oxides: SiO_2, Al_2O_3, Fe_2O_3, FeO, MgO, CaO, Na_2O, K_2O, and H_2O. An ordinary chemical analysis of an igneous rock gives the percentages of the different oxides present in the rock, but it does not indicate the form in which these oxides are present. For instance, an analysis of a pyroxenite may show some 14% CaO, and that of an anorthosite approximately the same amount, but the pyroxenite lime differs from the anorthosite lime in much the same way as red phosphorus differs from the yellow variety. What applies to lime applies to the other oxides that go to make up igneous rocks, with the possible exception of the oxides of iron. An ordinary chemical analysis of an igneous rock therefore does not give anything approaching such a complete account of the fundamental chemical constitution as is usually presumed.

The first point to be discussed therefore is the different forms of the various oxides. In Tables I. and II. are given some of the more important data in regard to the principal rock-forming oxides, along with those of a few other oxides that do not occur so abundantly but are nevertheless of considerable interest from the ore-deposit point of view. One of the columns in these tables gives the solid specific volumes of the oxides. The whole subject of solid specific volumes has been largely neglected in connection both with mineralogy and petrology. Dr. G. T. Prior presented a short paper to the Mineralogical Society * on the solid specific volumes of sundry minerals some sixteen years age, but despite the interesting and significant relationships which he disclosed, the importance of the matter does not seem to have impressed itself on geologists or mineralogists.

Before going any further it will be as well to inquire as to what precisely is implied in the term solid specific volume. For the sake of brevity the letters S.V.S. (solid volume specific) will in future be used instead of the full term. In chemical textbooks atomic volume, molecular volume, and specific volume have been used almost indifferently for the S.V.S. of various substances. The earlier writers applied the term atomic volume to elements and compounds indifferently. Later writers use atomic volume for elements, and molecular volume for compounds, but these terms are both open to objection, because they suggest that the numerical values are a measure of the volumes of the atoms or the molecules as the case may be.

The S.V.S. of a substance is the space occupied by a quantity of it proportional to its atomic or simplest combining weight, and is expressed by the quotient of this weight divided by the weight of unit volume, that is, the specific gravity of the substance. Thus for Na_2O, the formula weight is 62, and the specific gravity of the dense variety is 2·8. Then $62 \div 2{\cdot}8 = 22{\cdot}1$, the S.V.S.

It must not be presumed, however, that these so-called molecular volumes represent the relative volumes of the actual material atoms or molecules of different bodies. It seems improbable that atoms or molecules entirely fill up the space occupied by masses of them in the solid state; consequently the Sp. Gr., and therefore the S.V.S., will depend partly on the relative weights of the molecules and partly on the number of them confined in a given space, that is to say, on the magnitude of the interstitial spaces. Thus a change in solid specific volume may mean an alteration in the manner of packing of the molecules in the sense of a different kind of space lattice, or it may mean polymerization or condensation of simpler into more complex molecules, or the individual molecules may expand or contract. In many cases changes of S.V.S. may be attributed to polymerization, but in others, where the true molecular complexities cannot be determined in the present state of physico-chemical science, it is important to bear in mind that changes in density may be due to causes other than polymerization.

The S.V.S. of substances must therefore be clearly understood to be the spaces occupied

* Note on a Connexion between the Molecular Volume and Chemical Composition of some Crystallographically Similar Minerals. By G. T. Prior. *Mineralogical Magazine*, Vol. XIII., No. 61.

by aggregates of molecules or systems, including the interstitial spaces, whose weights are proportional to their simple combining weights. It has in fact been described as the space "inhabited" by the molecules.

On reference to the two tables it will be seen that the principal rock-forming oxides: SiO_2, Al_2O_3, Na_2O, K_2O, MgO, and CaO, as well as several of the minor constituents, have more than one S.V.S., that is to say, the same quantity of one and the same oxide can occupy quite different volumes under different conditions. It will be quite obvious that changes of volume without changes in ultimate chemical composition open up immense possibilities in connection with the general theory of igneous mechanics and magmatic differentiation. When the same substance can appear in different forms in this way it is said to be dimorphous, or polymorphous, as the case may be, and the phenomenon in the widest sense is described as allotropy. The allotropy of the rock-forming oxides is a matter that has been largely overlooked, but it appears to be one of the greatest importance in the general study of magmatic geology, since it co-ordinates many phenomena that have hitherto baffled the efforts of geologists to explain.

Unfortunately the allotropy of inorganic compounds is a matter requiring much more thorough investigation than it has hitherto received, so that the amount of information at present available is somewhat meagre. On account of the geological importance and the absence of any succinct treatment of the subject in petrological treatises, it will be as well to briefly present a few of the more salient points.

Both elements and compounds exhibit allotropy. Berzelius, who introduced the term, considered that it was probable that even in compounds the elements retain their allotropic states. For example, sulphur exhibits several allotropic modifications, and there is a good deal of evidence to indicate that this allotropy has its counterpart in the constitutions of various sulphide minerals. Silicon exists in different allotropic forms of varying densities, and it is noteworthy that silica exists in several allotropic modifications. The appearance of allotropy seems to be favoured by smallness of atomic weight, for it not infrequently happens that, in the same natural family of elements, allotropy shows itself principally in the first members.

Now oxygen is the first member of the oxygen-sulphur-selenium-tellurium family, all the higher members of which show allotropy to an unusually conspicuous degree. Ozone, a polymeride of oxygen, is essentially an allotropic variety of oxygen. Bearing in mind the position of oxygen in the family, the probable persistence of elemental allotropy into compounds and the fact that nearly half of the weight of the lithosphere is made up of oxygen and more than a quarter of silicon, it will be obvious that allotropy is a matter that the geologist can scarcely afford to ignore.

The production of allotropic modifications, and the transformations of one modification into another, are effected very commonly by changes of temperature. This is often described as enantiotropic allotropy. An allotropic change is not necessarily a sudden transformation of one form into another, since there is always the possibility that one or both forms may have a certain solubility in the other. So-called dynamic allotropy, in which the different allotropes can exist *in equilibrium* through a wide range of temperature, is well known to occur in the case of certain liquids; for example fused sulphur, which has been the subject of numerous investigations. The velocity of change of one form into another has been investigated in the case of liquid sulphur, and it seems probable that certain results are of wider application. It has been found, for instance, that the velocity of change of S_μ to S_π is very great at first, but that it diminishes to quite a small value when the concentration of Sm is small. The theory of dynamic allotropy has been extended of late years by Smits, and it is considered by him that different allotropic modifications of the same substance can exist side by side in equilibrium in the solid state in much the same way as they do in liquid sulphur.

In contradistinction to this dynamic allotropy is that in which one of the allotropic states corresponds to a specified interval of temperature, so that at a definite limit of temperature the one modification passes into the other. The inversion of quartz to tridymite may be cited as an instance of this. Nevertheless even in this kind of allotropy it is often possible to cool the modification belonging to the higher temperature below the lower limit, or even to heat the low-temperature form above the upper limit without transformation taking place. Tridymite as such, which is characteristically a high-temperature form of silica, is found in rocks as well as quartz, while it is not at all improbable that the tridymite allotrope of silica can exist as a relatively stable form at ordinary temperatures in combination or solid solution as a constituent of silicate min-

TABLE I.—ILLUSTRATING THE CHEMICAL CONSTRUCTION AND ALLOTROPY OF PRINCIPAL ROCK-FORMING BASIC OXIDES.

Metal	Atomic Weight	Specific Gravity	Solid Specific Volume	Oxide	Formula Weight	Specific Gravity	Solid Specific Volume	Expansion %
Na	23	0·97	24	Na 20	62	2·8	22·1	
						2·3	27·3	23·5
Mg	24	1·75	14	MgO	40	3·6	11·1	
						3·2	12·5	12·5
Al	27	2·6	10·4	Al 203	102	4·0	25·5	
						3·7	27·3	7·0
K	39	0·87	39·7	K20	94	2·66	36·6	
						2·3	40·5	10·5
Ca	40	1·55	26	CaO	56	3·4	16·4	
						2·5	23·4	42·5
Sr	87	2·6	33·5	SrO	103	4·8	21·5	
						?	30 ?	?
Ba	137	4·0	34	BaO	153	5·7	26·6	
						4·9	31·6	19·0

NOTE. — Determinations of the specific gravities of the metals by various investigators differ to some extent among themselves, so that the above figures of columns 2 and 3 are given as approximations and may be modified somewhat by future research. Barium and strontium are included in this list to show their analogies with calcium, although they do not occur as rock-forming oxides in anything more than subordinate amounts.

TABLE II.—SOLID SPECIFIC VOLUMES, ALLOTROPY, ETC., OF SUNDRY ROCK-FORMING AND ORE-FORMING OXIDES.

Mineral	Oxide	Formula Weight	Specific Gravity	Solid Specific Volume	Remarks
—	BeO	25	3·0	8·4	
Manganosite	MnO	71	5·1	14·0	
Polianite	MnO_2	87	5·0	17·4	
—	FeO	72	4·95	14·5	Calculated
—	FeO_2	88	5·5	16·0	Calculated
Hematite	Fe_2O_3	160	5·25	30·5	
Magnetite	Fe_3O_4	232	5·18	45·0	
Quartz	SiO_2	60	2·66	22·6	
Cristobalite			2·41	25·0	
Tridymite			2·31	26·0	
Quartz Glass			2·20	27·0	
Rutile	TiO_2	80	4·2	19·0	
Brookite			4·0	20·0	
Anatase			3·9	20·5	
—	ZrO_2	122	5·0	24·3	Amorphous
			5·1	24·0	Crystals, Moissan
			5·4	22·5	Ditto Knop
			5·7	21·3	Ditto Nordenskjold
Cassiterite	SnO_2	151	7·1	21·3	
	,,	,,	6·9	21·9	Artificial Crystals
	,,	,,	6·6	22·8	Artificial Crystals
—	P_2O_5	144	2·4	60·0	
—	La_2O_3	324	6·5	49·5	
—	B_2O_3	70	1·75	40·0	
—	Cr_2O_3	153	5·0	30·6	Amorphous
—			6·2	24·7	Crystalline
—	WO_3	232	7·2	32·3	Crystals, Zettnow
			6·4	36·2	Crystals, Nordenskjold

erals. When an allotropic variety in the free state is preserved above its fixed limit, the state of equilibrium of its particles is apt to be very unstable, and can often be destroyed by what appear to be the most trifling causes. A particularly easy means of upsetting equilibrium in some cases of this kind is to bring the substance into contact with a crystal of the modification that is stable at the prevailing temperature. Again, the form produced at high temperature may remain stable at low temperature, but become unstable by heating to the neighbourhood of the temperature of transformation. Aragonite, $CaCO_3$, which separates from hot solutions, is fairly stable at ordinary temperatures, but on heating it is transformed into calcite, which is the form produced from cool solutions, and this transformation takes place before dissociation of the $CaCO_3$ into CaO and CO_2.

When one allotropic modification changes into another, heat may be either evolved or absorbed and the thermal effect may be very considerable.

One of the most important changes that accompany allotropic transformations is the change in the space occupied by equal quantities of the same substance. It is this change and the thermal effects taken together that give to the problems of allotropy its peculiar interest to the general geologist and particularly to the student of ore deposits. In the case of the basic oxides, including alumina, the dense forms are the forms of higher potential energy, while in the case of SiO_2 in the free state the position is reversed.

With this general summary of the phenomena of inorganic allotropy by way of preface, we may proceed to consider the specific data relating to the different forms of the rock-forming oxides and their congeners.

Ditte investigated MgO. He found that the density of this oxide rises rapidly with temperature, and he gives the following figures: at 350°C, 3·1932; at dull red heat, 3·2482; at bright red heat, 3·5699; fused oxide, 3·654. He concluded that there was a continuous variation in density with increasing temperature right up to the fusion point and he attributed these volume changes to polymerization.*

Alumina, Al_2O_3, shows similar variations in density. The following figures are given in Landolt's tables: slightly ignited alumina, 3·73; amorphous, 3·85; strongly ignited, 3·99. Sapphire and ruby have densities in the neighbourhood of 3·95, and corundum usually about 4·0.

Zirconia, ZrO_2, though not a principal rock-former, but a very common accessory combined in the form of zircon, shows a similar series of changes. The figures are given in Table II. It was thought at one time that the variations in density of this oxide were due to incomplete de-hydration, but the work of Nordenskiold and others shows that it is a case of allotropy comparable with the others. Now zirconia, although inclined to be acidic in its properties, acts like a base in regard to its allotropy in that its density increases with rise of temperature. Silica, the principal acidic oxide of igneous rocks, acts in the reverse way as regards its allotropy, for the high-temperature forms of silica are of lower density than the low-temperature stable form, quartz. The density of zircon is notoriously variable, but the lighter forms increase in density by prolonged ignition, whereas the heavier forms are practically unchanged by ignition. This simple mineral therefore affords useful corroboration of Berzelius' view that the allotropy of substances persists in their combinations and occurs in the silicates, which are the principal type of rock-forming minerals. It is also of interest to note that the direction of the change accords with that of the base and not that of the acid in this instance.

Another point of importance in connection with these allotropic modifications is that the expanded forms correspond with the hydrate condition, that is to say, hydrated magnesia, alumina, zirconia, etc., are made up of the expanded form plus water.

The allotropy of lime, CaO, has not been carefully studied with a special view to its elucidation as was the case with the oxides previously discussed, nevertheless its existence rests on a firm basis. Moissan obtained cubic crystals having a density of 3·4. Brugelman obtained crystals of density 3·25. Heated to 1,500°C. Moissan obtained CaO of density 3·30. In experimenting on the production of calcium carbide, Jouve produced perfectly transparent prismatic needles of CaO, which he was able to isolate and analyse. He found them to contain 98·5% CaO with a little carbide of calcium as impurity. He found their density to be only 2·5 as compared with cubic crystals 3·32. These crystals were very unstable and quickly absorbed CO_2. Commenting on the conditions under which these crystals were produced, he remarked that they appeared to result from the cooling of lime *in a confined space* in the presence of the furnace vapours.*

Now it was pointed out that the expanded form of the other oxides was that in which it was present in their hydrates. When ordinary burnt lime is slaked the mass swells and crumbles, and there is a great evolution of heat. If, however, we analyse the density of $Ca(OH)_2$, which is only about 2·1, on the assumption that the lime is present not in the expanded form as was the case of the other oxides but in the dense form, then we find that there has been practically no contraction on hydration, though as a general rule there is a considerable contraction on addition of the first molecule of water of hydration.

Now the heat of slaking of lime is usually regarded as the heat of hydration of the anhydride comparable with a heat of hydration

* Ditte. *Comptes Rendus*, lxxiii., pp. iii & 270.

* Jouve. *Comptes Rendus* 1901. Vol. 132. p. 1117.

involving no other change than a simple addition of water. When we come to analyse the phenomena presented by CaO and its monohydrate, either we must regard it as an exception to the usual rules of hydration, which is not a good principle to go on in interpreting a phenomenon that can easily be brought into line without such an appeal, or we may regard the slaking of lime as the combination of hydration with allotropic change and the various phenomena are fully explained and are on the same footing as the other oxides.

By way of corroboration we may appeal to the more general facts of inorganic allotropy and consider how they work out when applied to certain lime compounds. One of the most mysterious and vexed problems in industrial chemistry is that of the setting of cements, such as portland or the Sorrel cements. In the recent symposium on cements at the Faraday Society allotropy seems to have practically escaped notice.

Now it was pointed out that in cases of dynamic allotropy the velocity of change greatly diminished with the diminution in concentration of the metastable phase. Applying this to the phenomena of the first and after setting of cement, it is easy to understand both the quick and slow setting, and how it comes about that cements increase in hardness with age. The transformation of aragonite to calcite has already been referred to.

Baryta, BaO, confirms the allotropy of CaO, for there are two forms of baryta having widely different densities. The figures are given in Table I. In the case of strontia only one form appears to be known, but it seems probable that this arises from lack of investigation. Thus although the facts in regard to lime differ in detail from those of the oxides previously discussed, they are sufficient and more than sufficient to establish that the S.V.S. of CaO may vary between wide limits as well as the conditions that tend to promote the transformations. In fact it appears that lime may act as one of the most drastic and violent blasting agents in the whole magmatic laboratory, for it has to be particularly borne in mind that seemingly trifling causes can effect allotropic changes, while in the case of lime in particular the change of volume may be exceptionally great, and the heat evolution relatively intense. It is worth noting in this connection that a form of "lime blasting" by driving steam into cylinders of quicklime is used in coal-mining operations.

In the cases of K_2O and Na_2O the information available in regard to their allotropy is rather more meagre, but is amply sufficient to establish its existence. According to Karsten the density of K_2O is 2·656. Liddle's tables give 2·56, while fairly recent determinations by Rengade gave 2·32. Similarly for Na_2O Liddle's tables give 2·8, while Rengade found 2·27. Bearing in mind the conditions of preparation of these oxides in the anhydrous condition, analogy indicates that it is probably easier to produce the denser form than the lighter. Determinations of the density of NaOH also show great variations. Here again there is a very great evolution of heat on adding the anhydrous oxides to a small amount of water, and it remains to be proved whether the heat evolved by dissolving KOH and NaOH in water may not in part be due to further allotropic change in the anhydride.

The foregoing presents the main facts in regard to the allotropy of the rock-forming oxides so far as they appear to be known at present, but as remarked at the outset the subject of inorganic allotropy is one that urgently needs more serious and exhaustive investigation, especially as it is implicated in the chemistry of such important industries as cement making, and consequently ferro-concrete construction, potash extraction, and similar matters of far-reaching importance.

Figure 1 is a graph in which the expansions on allotropic transformation are plotted against the simplest combining weights of the different basic oxides. On examining the columns giving the S.V.S. of the metals and their oxides given in Table I it will be observed that with the exception of Al_2O_3 the S.V.S. of the metals are greater than those of their oxides. It is worthy of note in this connection that these metals, according to the calculations of Richards, are characterized by exceptionally high compressibilities, and it was in connection with them that Kopp found that it was necessary to assume a widely different S.V.S. in combination from that of the metals in the free state.

In Figure 2 the S.V.S. of the principal rock-forming oxides are plotted against their simple combining weights, and a curve drawn connecting the basic oxides. It brings out an important relationship, namely, that the combining weights are a periodic function of the S.V.S. In this graph the allotropic changes in volume are indicated by horizontal broken lines, while SiO_2 is indicated as a separate broken line, it being the principal acid in contradistinction to the basic oxides, though as remarked previously Al_2O_3 acts both as acid and base in rock magmas. Fe_2O_3 probably acts both as acid

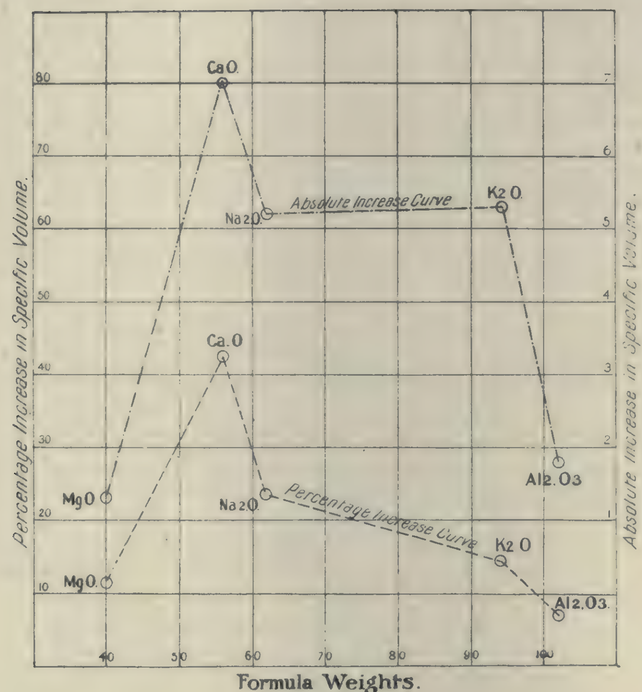


FIG. 1.

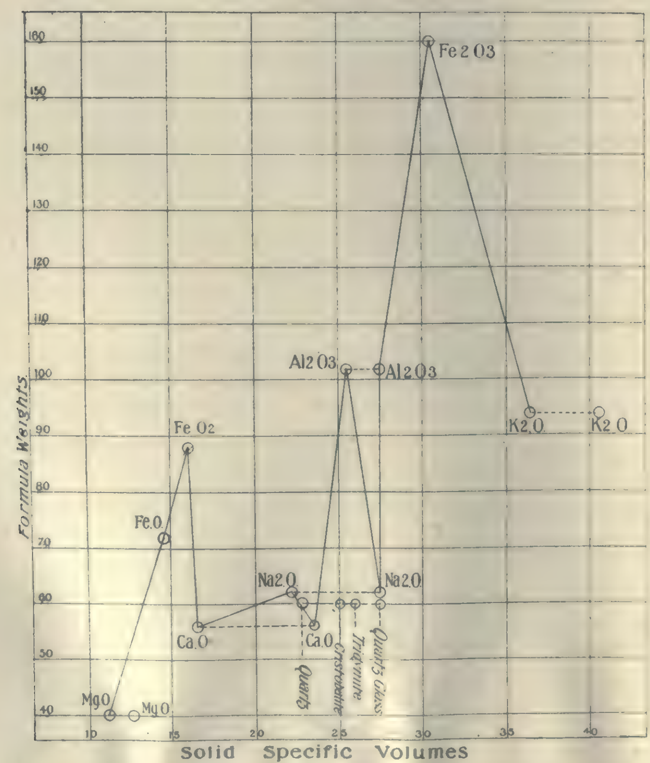


FIG. 2.

and base in similar fashion. In recognition of this, Fe_2O_3 appears twice in this plot, namely, as FeO_2 supposedly dissolved in 2FeO, and as Fe_2O_3. Examining the general order of the basic oxides only it is worthy of note that those bases that are highly soluble in water lie to the right of Al_2O_3 in the figure and the sparingly soluble oxides to the left. In a broad way and omitting Al_2O_3 the order proceeding from left to right is the order of aqueous solubility of the basic oxides. To the left of the figure are the "insolubles," and these are the constituents of the ferromagnesian group of minerals, while toward the right are the soluble oxides which appear chiefly in the felspars. In the middle is the hybrid acid or basic oxide Al_2O_3 which may appear either in the ferromagnesian or the felspar group, while the semi-soluble basic oxide lime forms a connecting link between the practically insoluble oxides of magnesia and iron on the one hand and the highly soluble oxides of sodium and potassium on the other. There is thus a relationship between S.V.S., aqueous solubility, and the normal order of crystallization of the oxides, in the shape of silicate minerals, from rock magmas that cool under plutonic conditions.

It is worth noting therefore that the solubility of MgO in aqueous solutions is increased by the presence of salts of the alkali metals. FeO is usually described as "insoluble" in aqueous solutions as well as $Fe(OH)_2$, and as insoluble in caustic alkali solutions. Ferric oxide, however, is to some extent soluble in alkaline solutions under certain conditions. CaO hydrated is more soluble in cold than in hot aqueous solutions, but in the presence of various alkaline salts the position is reversed. Al_2O_3 hydrated is easily soluble in caustic alkalies, while dry fusion of Al_2O_3 and alkalis gives aluminates.

If we examine the general bathymetric distribution of the rock-forming basic oxides, it would appear that in a broad sense the outer or granitic shell of the earth is composed of the oxides of large S.V.S. and high aqueous solubility, while the general tendency seems to be for the inner or deeper regions to be made of the less soluble oxides of lower S.V.S.

In Figure 3 the various oxides are arranged in order of their S.V.S., and the radii of their spheres is given. The bathymetric distribution of the basic oxides in the silica sea according to size recalls in a distant way the phenomena of stratification. On the margin or shore of the ocean there are the larger sized particles, and the average size diminishes with increasing depth or distance from the margin. The processes whereby the differentiation is effected are widely different in the two cases, but it is interesting to note that the same idea of sorting into sizes recurs in igneous as well as in sedimentary geology. It will be shown later that a similar kind of size distribution and solubility relationships can be traced in connection with the constituents of ore deposits.

The miscibility of the constituents of rock melts is a matter of some importance, especially as there has been a disposition to suppose that magmatic differentiation may be effected by the splitting of silicate magmas into immiscible portions. The S.V.S. relationships of the oxides are of considerable interest in this connection. The S.V.S. of the rock-forming oxides in the free state are approximately, if not actually, the volumes with which they combine to form the various rock-forming minerals. Silicon belongs to the carbon group of elements, and the chemistry of silicates may be expected to show some family resemblances to that of the carbon compounds. The miscibility of various organic substances has been the subject of numerous investigations. Holmes* has put forward a mechanical theory of miscibility, as the result of his researches, that seems to fit in well with the facts in regard to the liquids which he investigated. After pointing out that the current theories of solution afford little, if any, explanation of the simpler facts associated with solution, such as relative solubility, volume changes, heat production, etc., he assumes the liquid molecules of different liquids to be "molecular spheres" having different radii, the radius being a specific property of the molecules of any particular liquid. From geometric considerations he concludes that in equimolecular mixtures if the ratio of the radius of one of the molecules to that of the other does not exceed 1·618 to 1 then the liquids are miscible in all proportions. A rock magma is of course far more com-

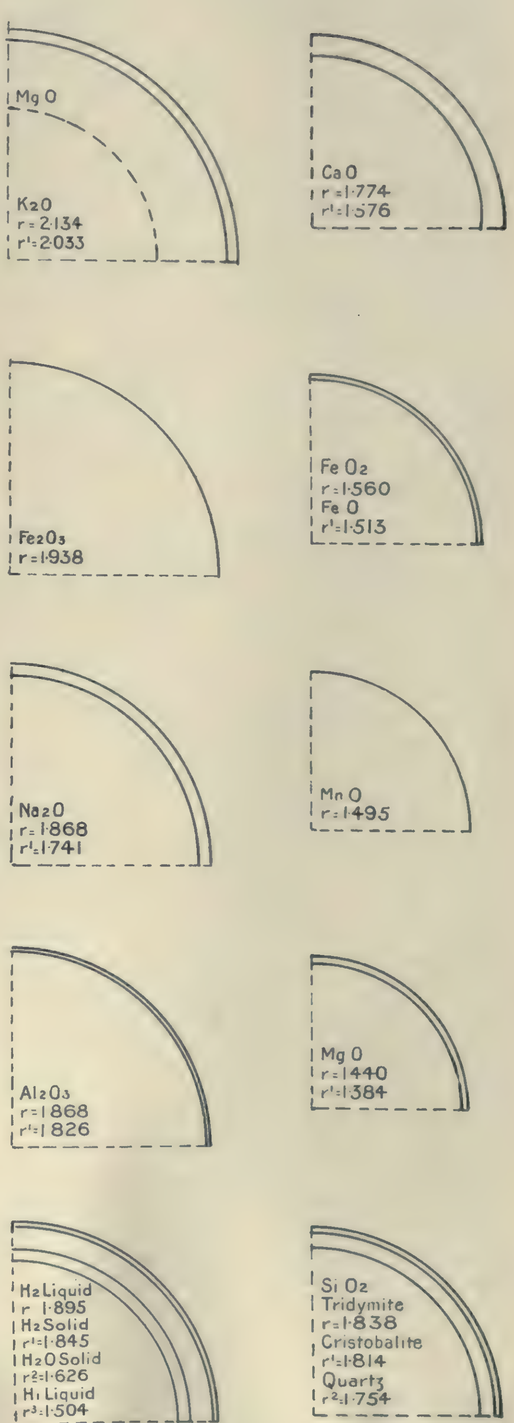


FIG. 3.

* Contributions to the Theory of Solutions. T. Holmes, *Journal Chem. Soc.*, Vols. ciii & civ., p. 2147, et. seq.

plex than anything he investigated, but it seems worth noting that the ratio of the radius of K_2O calculated from the S.V.S., which is the oxide of largest S.V.S., to that of MgO, which has the smallest S.V.S., is 1·5, and consequently less than 1·618. The broader aspect of Holmes' theory of solutions and miscibility, if the theory is generally applicable, would thus seem to point to the general miscibility of the oxides that occur in rock melts in all proportions. The ready miscibility of the oxides in widely varying proportions is of course implied in the mere fact of fusion and in the way they are blended in such complex and variable minerals as the pyroxenes, hornblendes, micas, etc., but that the influence of the S.V.S. of the constituents is of great importance stands out very clearly when the manner of blending of the constituents into complex systems, such as those just mentioned, is analysed.

Table III. gives the S.V.S. of some of the less common constituents of rock-forming minerals.

Constituents of quite a different chemical type may be blended into silicate minerals provided their S.V.S. fit in easily with the other constituents. Sodium sulphate for instance is a constituent of nosean, and its S.V.S. is just twice that of the hydrate forms of Al_2O_3 and Na_2O respectively. Sodium chloride, or common salt, has approximately the same S.V.S. as Na_2O (hydrate allotrope) and is thus easily blended into such minerals as sodalite. Aluminium fluoride has approximately the same S.V.S. as Al_2O_3 and thus is easily able to blend with it to form such minerals as topaz, which is such an important paragenetic associate of cassiterite in many tin deposits. Cassiterite itself is of interest in this connection, for although its density is so greatly different from that of the quartz with which it is usually associated, its S.V.S. closely approximates that of quartz. Consequently it is apt to replace SiO_2 or to be caught up to some extent in the making of complex silicate minerals and to appear in micas and similar complex systems instead of being left available for concentration into the residual liquors that at a later period in the magmatic crystallization scheme give rise to the stanniferous veins and impregnation deposits. In basic rocks, where the shortage of of acid oxides to satisfy the affinity of the bases is acute, tin oxide is apt to be entirely used up in the making of the principal rock-formers, and then turns up in the olivines or pyroxenes, so that its concentration into ore deposits is then effectively inhibited.

TiO_2 affords an even mere striking example since it is a much more common constituent of rock melts. Here again, although the density of TiO_2 is considerably greater than that of SiO_2, its S.V.S. closely approximates that of SiO_2. Considerable quantities of it are often taken up in lieu of SiO_2 in the building of such complex systems as the micas, hornblendes, pyroxenes, etc.

TABLE III.—SOLID SPECIFIC VOLUMES, ETC., OF SUNDRY CONSTITUENTS OF ROCK-FORMING MINERALS AND MAGMATIC SOLUTIONS.

Substance	Formula Weight	Sp. Gr.	S.V.S.
Na_2CO_3	106	2·5	40·2
NaCl	58·5	2·16	27
		(at m.p.)	
		1·6	
Na_2SO_4	142	2·6	54·6
NaF	42	2·9	14*
NaOH	40	1·72	23·3
		also	
		2·13	18·7
$Na_2B_4O_7$	202	2·36	85
Li_2O	30	2·1	14·2
KCl	74·5	1·98	37·5
		(at m.p.)	
		1·61	
K_2SO_4	174	2·66	65
KF	58	2·54	23
		2·1	27·6
		at 21·5°	
KOH	56	2·1	26·7
AlF_3	84	3·1	27·2
CaF_2	78	3·0	26·0
		also	
		3·25	24·0
$CaCl_2$	111	2·2	50·2
$Ca_3P_2O_8$	312	3·05	102·3
$CaSO_4$	136	2·98	45·5
$MgSO_4$	120	2·71	44·2
$MgCl_2$	95	2·18	43·7

* Calculated from cryolite as Sp. Gr. does not appear to have been determined.

In fact it would seem that in the architecture of many mineral complexes molecular weight and what are usually considered as chemical properties seem to be to some extent subordinated to considerations of size and shape, that is to say, physical properties. It is as if in the construction of a building the colour and weight of the bricks did not much matter provided the size and shape fitted in sufficiently well with the structural requirements. Nevertheless there is some geological evidence to suggest that the inclusion of TiO_2 instead of SiO_2 in this way tends toward instability, and the matter is of interest in connection with the formation of some large deposits of titaniferous iron ore.

This approximation of volumes shows itself in an even more elemental way in the construction of some of the simpler constituents of rock melts. The S.V.S. of metallic iron is 7·2 and that of FeO 14·5. That is to say, FeO consists of approximately equal volumes of iron and oxygen. Similarly for SiO_2 in the quartz form. The S.V.S. of silicon is 11·2 in its dense form. The S.V.S. of quartz is 22·6 or approximately double that of silicon. Here the phenomena are of a somewhat different kind, for the volume of the oxygen is different in the two cases, but the space occupied by the oxygen is determined by the "metal" in such a way as to make it equal, or approximately equal, to that of the metal. This kind of volume relationship was noticed by Schröder many years ago, but does not seem to have been recognized in the case of these rock-formers. It seems not improbable that the allotropic transformations of SiO_2 may be connected with allotropic changes of the silicon accompanied by corresponding adjustment in the oxygen volume in the sense of equalization of volumes.

It is interesting also to note that TiO_2 shows slight divergences both in respect to the approximation of volumes of Ti to O_2 as well as in the degree of difference between the S.V.S. of TiO_2 and SiO_2. This kind of approximation of volumes also has its counterpart in the construction of highly complex minerals as well as in these simple oxides, for by evaluating the volumes from the chemical analyses of several complex minerals containing a large number of oxides mixed together in an apparently promiscuous fashion, it can be shown that the sum of their volumes approximates very closely to that of the SiO_2. Thus the silica is expanded or contracted, as the case may be, to approximate its volume to that of the bases.

It is hoped that sufficient has been said to indicate the importance of volume study on quantitative lines in connection with the problems of magmatic differentiation, for it cannot be supposed that many of these volume changes are effected at any other time than during the course of cooling and differentiation of the magmas that are the source of our ore deposits. They show quite clearly that the cooling of rock magmas is not only accompanied by contractions but that expansions of a very high order are apt to be involved It is to the varying degrees of balancing of these opposing volume changes that many of the structural features both of ore deposits and igneous rock formation are to be traced, and many other magmatic phenomena.

Having now examined some of the more important properties of the constituents of the rock-forming minerals and the ways in which these simpler systems are built and compounded, we may proceed to elucidate the constructional chemistry of the more important rock-forming minerals.

(*To be continued*)

Mineral Output in 1917.

We give herewith the preliminary reports on the output of minerals in the United Kingdom during 1917.

TABLE I.—OUTPUT AND NUMBER OF PERSONS EMPLOYED AT MINES UNDER THE COAL MINES ACT.

	1916	1917
	Tons.	Tons.
Barium (compounds)	8,973	9,101
Clay and shale, other than fireclay and oil shale	177,719	156,804
Coal	256,348,351	248,473,119
Fireclay	1,712,281	1,888,592
Igneous Rocks	108	389
Iron pyrites	9,496	7,760
Ironstone	5,648,602	6,280,194
Limestone	2,477	13,983
Ochre and umber	44	—
Oil shale	2,994,386	3,113,003
Ganister	160,513	177,114
Total	267,062,950	260,120,059
Number of persons employed:		
Underground	792,911	811,510
Above ground	205,152	209,830
Total	998,063	1,021,340

TABLE II.—OUTPUT OF MINERALS AND NUMBER OF PERSONS EMPLOYED AT MINES UNDER THE METALLIFEROUS MINES ACT.

	1916	1917
	Tons.	Tons.
Arsenic	2,534	2,574
Arsenical pyrites	—	378
Barium (compounds)	60,468	50 591
Bauxite	10,329	14,724
Chalk	160	—
Chert, flint, etc.	3,202	2,957
Clay and shale	84,168	68,179
Copper ore and copper precipitate	937	1,109½
Fluor spar	34,547	43 934
Gold ore	1,338	—
Gravel and sand	8,575	10,092
Gypsum	188,801	144,682
Igneous rocks	23,875	11,602
Iron ore	1,752,614	1,733,753
Iron pyrites	985	755
Lead ore	17,084	15,312
Lignite	500	900
Limestone	235,983	208,017
Manganese ore	5,140	9,942
Ochre, umber, etc.	4,790	5,799
Rock salt	129,030	122,679
Sandstone	(*a*) 32,174	(*b*) 33,772
Slate	46,184	37,220
Soapstone	301	1,233
Tin ore (dressed)	6,161	5,262
Tungsten ores	388	237
Uranium ore	51	13
Zinc ore	8,476	7,484
Total	2,658,795	2,533,200½
Number of persons employed:		
Underground	11,858	12,476
Above ground	7,597	8,024
Total	19,455	20,500

(*a*) Including 8,497 tons of ganister.
(*b*) Including 16,797 tons of ganister.

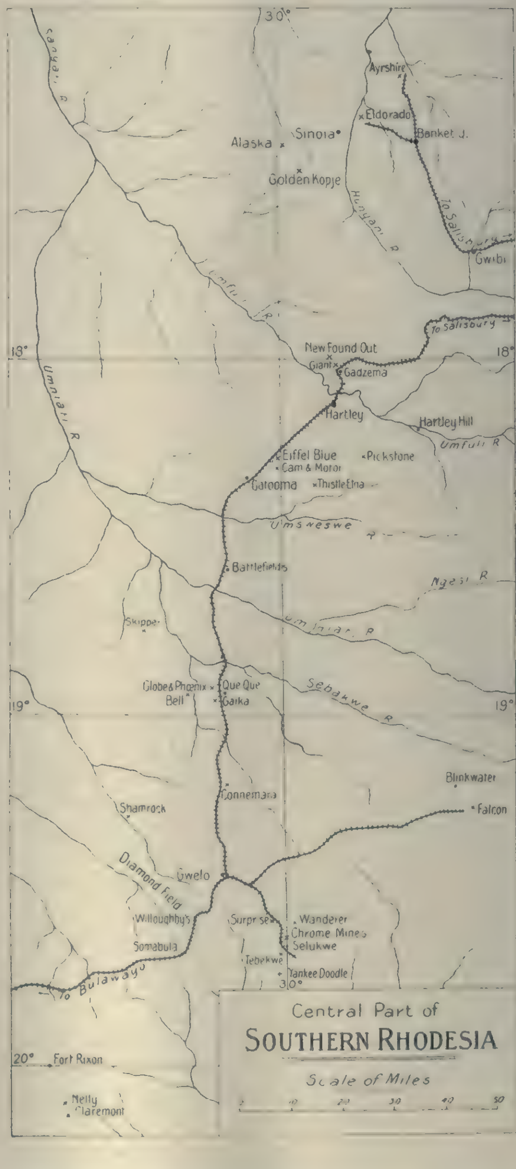
NEWS LETTERS.

SALISBURY, RHODESIA.

March 12.

GAIKA GOLD.—The depression due to the war has been reflected lately in a general absence of news regarding mining developments. This has been especially the case with the gold-mining section of the industry, which still preponderates considerably over our other mineral products as regards output. The only outstanding feature of recent developments has been the striking of a rich shoot of ore at the south end of the Gaika property. This has now resolved itself into a quartz body having a length of about 200 ft., its continuance downward having yet to be traced. The fact that it consists of quartz is to be noted, as the greater part of the ore at this mine consists of dolomite or talc-schist. Its well known neighbour on the north, the Globe & Phœnix, has provided what is so far the best Rhodesian example of persistence in depth, and the ore-body is typical vein quartz. At the Gaika, on the other hand, the pay rock has not shown the same tendency to persist downward for more than a few levels, and the shoots are irregularly distributed through an extensive zone of mineralization. They consist as a rule of rock similar to that which forms the country of the Globe & Phœnix. It does not, however, follow from what has been said that the prospective life of the Gaika is necessarily more limited than that of its neighbour, for the mineralized zone is extremely large; but it depends rather on its lateral extent, whereas the life of the Phœnix is entirely a matter of extension in depth. The ore-shoots on the Gaika have taken a large amount of work to open up, but they are usually of high grade, a fact which has often been obscured in the returns owing to a large percentage of the material crushed being low-grade surface, locally known as "rubble." The rubble, by the way, that is worked on this, and a considerable number of other Rhodesian mines, is not a natural product of the disintegration of the outcropping ore-bodies, as might perhaps be expected. It consists chiefly of rock mined by the "ancients," who preceded the modern miner almost everywhere in this country. This serves to illustrate one of the difficulties attending the limitation of the term "ore." It is, in fact, the stuff that was discarded as waste, and has remained to the present day scattered about the surface in heaps.

ASBESTOS.—The depression which has characterized mining for gold has to some extent been relieved by a certain amount of activity in opening up deposits of the base metals and non-metallic minerals. The development of asbestos properties, in particular, has proceeded apace, and it is scarcely possible to meet a prospector who has not got specimens of that valuable mineral somewhere about his person. The activity displayed in the search for new asbestos deposits may incidentally result in discoveries of other minerals favouring the same class of country. Meanwhile the flotation of the new asbestos corporation should tend to promote a rapid expansion of the output of fibre, as it will no doubt lead to a period of steady work after a long interval of financial uncertainty. The entry of Rhodesia into the asbestos industry is entirely due to the enterprise of a small Bulawayo syndicate, which in spite of many initial difficulties succeeded in proving the value of what remains the most important property in the Victoria district. This was disposed of in 1908 to an English concern known as the T.H.S. Syndicate, this in turn giving place to the Victoria (Rhodesia) Asbestos Company. Very little was accomplished by either of these companies, and the claims were handed over on option to the Charterland & General Exploration Co. Now we have the new company with the imposing capital of £400,000. Local criticism of the new company is not based on the idea that this represents undue inflation, more especially as new deposits of very



great promise are included in the flotation. They are grounded on a suspicion that the changes of the past had as their aim the "freezing out" of the original pioneers of the asbestos industry. However this may be, it is hoped that the new concern with its ample capital will prove in the long run a powerful factor in the progress of what is undoubtedly destined to be a most important branch of the Rhodesian mining industry.

TORONTO.

PORCUPINE.—Operations at Porcupine are showing increased activity, consequent upon the improvement in the labour situation. It is believed that economic conditions, which greatly retarded production last year, have reached their worst. Important changes have been made in the staff of the Hollinger Consolidated, the position of general manager having been accepted by A. F. Brigham, a mining engineer who has occupied prominent positions in South Africa, having latterly been general manager of the Jagersfontein diamond mines. A. R. Globe, who has also had much South African experience, has been made assistant general manager. P. A. Robbins will retain the post of managing director. The company has now approximately $1,250,000 in the treasury, and net earnings are maintained at about $200,000 per month, but will for the present pursue a conservative policy and continue adding to its surplus, until conditions become sufficiently favourable to justify the resumption of dividend payments. The Dome Mines is continuing the work of development with a small force of men. The main shaft has reached a depth of 1,300 ft. Milling has not yet been resumed. The Davidson is now a producing mine with a 10 stamp mill in steady operation. A high-grade ore-body 18 in. wide has been encountered on the 100 ft. level, and a great width of good milling ore has been developed. The McIntyre has secured a controlling interest in the Newray, where the Hansen vein has been opened up for 140 ft. on the 400 ft. level and has widened out in places with gold content averaging $10 per ton. The McIntyre mill is treating about 600 tons of $10 ore per day.

COBALT.—Stimulated by the high price of silver the leading silver mines are being worked to capacity. Labour is plentiful and the output is showing a considerable increase. The annual statement of the McKinley-Darragh shows net profits of $259,794. Reserves decreased during the year from 1,714,302 oz. to 1,076,182 oz. A large area of ground on the 300, 350, and 400 ft. levels has yet to be explored. The surplus amounted to $242,514. The La Rose Consolidated is pushing development on the Violet property with fairly satisfactory results on the 410 ft. level. The vein system is heavily mineralized, but the silver content is low. At the Chambers-Ferland a high-grade vein recently found at the 280 ft. level is being followed up and proves to be one of the most important ore-shoots yet discovered on this property. Large quantities of high-grade ore are being extracted. The Genesee, in cross-cutting at the 500 ft. level to pick up veins continuing from the Chambers-Ferland, has struck a 2 in. vein well mineralized. The Timiskaming mill is running at reduced capacity, having only ore for three months ahead. A geological survey is being made preparatory to further exploration. A new mill has been built at the Casey-Cobalt in Casey township, and diamond-drilling is in progress. The Airgoid property is being explored by the Three Stars Mining Co.

KIRKLAND LAKE.—The Tough Oakes had an unprofitable year in 1917, the annual statement showing a deficit of $79,062. The total earnings were $340,086 and operating and general expenses $419,147. Latterly with the improvement of conditions the company's position has been bettered, and the outlook for the present season is more favourable. The Elliott-Kirkland has encountered a rich paystreak, from 1½ to 2 ft. in width, at the 425 ft. level, the vein also showing a considerable width of commercial ore. Rich ore is also being developed at the Burnside on the 100 ft. level, where assays are reported to show $127 to the ton over a width of one foot. The new mill at the Lake Shore has been put into operation and has developed a capacity of 60 tons per day, with mill-heads averaging $23 per ton. The Wright-Hargraves has cut a station at the 300 ft. level, where the width and grade of the ore are well maintained. The shaft is being sunk further.

BOSTON CREEK.—At the Patricia excavation has been begun for the mill which is expected to be ready for operation in September. No. 1 shaft is down 140 ft. and No. 2 shaft has reached a depth of 100 ft., at which level lateral work is under way. The ore has an average width of 40 in.

OIL FOR FLOTATION.—The scarcity of pine oil for flotation purposes, which threatened seriously to interfere with milling operations where this process has been adopted, has been overcome owing to an important discovery made at the Forest Products Laboratory of the Canadian Government. Experiments were carried on for some months to ascertain whether pine oil, hitherto supplied from the Southern States, could be successfully produced from Canadian pine. The problem was satisfactorily solved, and it was also discovered that a cheap substitute could be found in a creosote oil thrown off as a by-product in wood distillation. This will secure for the silver and other mining companies employing the flotation system an ample supply of oil at a greatly reduced price.

CAMBORNE.

LABOUR QUESTIONS.—A state of affairs has recently arisen which well illustrates one of the most objectionable features of the trade union movement, and one which does much to alienate the support of thoughtful people, who would otherwise be quite ready to recognize the value and usefulness of labour co-operation. It appears that some of the union members have got into arrears with their subscriptions, advancing the reason that non-union men appear to get the same advantages in the matter of pay as union members, and consequently there was little, if any, advantage in membership of the union. This determined the local leaders to adopt coercive measures, which certainly savour of Prussianism in all its nakedness. This was no less than to demand that the mine managements should dismiss all non-union labour on the threat of a "down tools" action on the part of the unionists. In the case of one mine, at any rate, the manager was requested even to dismiss the union defaulters unless the arrears were paid. Of course, the managers had little option but to decline to be intimidated in this fashion, and the result was a series of short strikes at some of the mines. However, on the advice of headquarters, the men resumed work, and the union has referred the question to the Government Labour Department. It will be interesting to see what action that Department takes, especially as, according to the press, only recently in south Ireland a somewhat similar set of conditions arose, in which the Government took a most decided stand against coercion. In this case, the Government were constructing a large aerodrome, and in sympathy with the Irish "no conscription" protest, several hundred men employed thereon ceased work for a day. A half dozen men, however, worked as usual, and when the demonstrators returned, they insisted that these six men should be dismissed as a condition precedent to their resuming work. The authorities declined to comply and paid off all hands. One wonders whether the Labour Department will have the courage also to refuse to support the union demand to which I have referred.

SOUTH CROFTY.—In another part of this issue, particulars are given of the Castle-an-Dinas wolfram property which has been acquired by South Crofty, as briefly stated in the last issue. This property has been prospected and developed for the late owners under the supervision of Captain Josiah Paull, and he has expressed the opinion that "it is by far the best purely wolfram property in the County of Cornwall." There is general agreement that it is a most promising proposition, and in view of the recognition by the Government that the production of tungsten is a "key" industry, and one which will be given every encouragement and support even after the war, there can be little doubt that the purchase will be advantageous to the South Crofty shareholders.

DOLCOATH.—In the last issue, reference was made to the excellent profits earned by the East Pool and South Crofty companies in operating their mixed ores. Now we have in Dolcoath an almost purely tin proposition, and the profit earned for the six months ended December 31 last clearly proves the statement recently made in these colums that Cornish mines, whose sole product was tin, were by no means doing well, in spite of the high price of that metal. This is, of course, mainly due to the dearth of miners, and also to the increased wages and abnormally high price of all materials; indeed, Captain Arthur Thomas is responsible for the statement that Dolcoath could be worked to much greater advantage before the war than is now possible. Basset is another case in point, to which, however, I shall refer later.

For the six months under review, Dolcoath produced 467½ tons of tin concentrate from 34,540 tons of ore milled, or an average recovery of 30·32 lb. per ton, as compared with 31·85 lb. for the previous half-year. The average value for tin per ton of ore was 39s. 3d., against 35s. 10d. for the previous six months, so that the fall in metallic content was more than neutralized by the higher price realized for the product. The total value of the ore was 41s. 7d. per ton, and the working cost 38s. 1d. (including 2s. 8d. per ton for royalties, but excluding depreciation), so that the gross profit equalled 3s. 6d. per ton, or a total of £6,055. After the current half-year, royalties will disappear, owing to the purchase by the company of the mineral rights. The substitution of debentures for mineral lords, it is estimated, will result in a saving of £4,500 to £5,000 per annum, so that the purchase of the Tehidy mineral rights, apart from the splendid possibilities of the outside areas, would have been good business on that saving alone.

The most lamentable feature of the whole report is the reduced development footage, only 80 fm. compared with 180 a year ago. At a time when development is more needed than at any other period in the history of the company, it is most unfortunate that dearth of labour makes it impossible to carry out such work, and at the same time operate the mine without loss. It would, as Captain Thomas stated at the shareholders' meeting, be nothing less than a national calamity if mines in Cornwall were allowed to go under through lack of labour, and certainly, the Government Department concerned will be lacking in foresight if it allows the military authorities to skin the industry of further men. Mines cannot be closed and re-opened like drapers' shops, and the Chamber of Mines might usefully press this matter even as far as the War Cabinet. The embargo placed by the Dutch Government on tin from the Dutch East Indies will doubtless make the authorities better appreciate the value of the tin-mining industry of Cornwall.

Vigorous use is being made of the diamond-drill for testing the most promising of the undeveloped lode areas, and to date 3,210 ft, has been drilled. One hole was put out a distance of 530 ft. south, east of the cross-course, with a view to locating the faulted section of the main lode. The lode was found to be 19 ft. wide, and the cores indicated the present of rich values over a small section. Evidently this is a promising development point when labour is available. The drill is at present being employed at the 190 north of New Sump shaft with a view to locating the North Entral lode, which is the western extension, south of the cross-course, of the South Crofty lode, and it is obvious to anyone who has studied the plan, that the possibilities in the northern section are considerable. Lateral development is now the order of the day at Dolcoath, and it will be recalled that this is a policy which has been advocated in this Magazine for some years past. The upper levels of the mine are still being re-opened for arsenic, and the income from this source for the past half-year was £2,191, while an increase on this figure may be expected for the current six months.

TINCROFT.—The issue of share bonuses just now seems a popular policy, and a scheme is now afoot in connection with this company to get rid of the preference shares by allotting three ordinary shares for each preference share now issued. The present capital of the company is £37.500, divided as between 100,000 ordinary shares, and 50,000 preference shares, both of 5s. denomination. Including the 1s. dividend just paid, the priority shares are still entitled to receive 13s. 6d. per share by way of dividend before the ordinary shares rank for dividend. To remove this preference, and so enable the ordinary shareholders to participate in the substantial profit now being earned, the proposal is to have only one class of share, which has its advantages, and will most certainly result in a freer market for the shares. The accretion in market value of the ordinary shares to 12s. has made this scheme possible, and doubtless Treasury consent will not be necessary for a reorganization of this character.

GRENVILLE.—The shares of this company have recently come into demand, and have practically doubled in market value, doubtless on the opening up for stoping of the block of good ore disclosed between the 375 and 395 fm. levels west of Fortescue's shaft, which was referred to in the last report. Water troubles have delayed the development of this ground. The mine is self-supporting once more, although doubtless a fairly heavy loss will be disclosed in the accounts for the six months ended December 31 last, now about to be issued, and with higher values, plus the advance in the price of the metal, the position should continue to improve. The market price of the shares has hitherto not represented the old-iron value of the machinery. Grenville has before now been the only bright spot in the Cornish firmament, and a return of past glories would be very welcome.

BASSET. — The accounts of this company for the year ended December 31 last show a loss of £1,523, without any allowance for depreciation of plant and machinery, and the manager's report discloses nothing to dispel the rather gloomy feeling one gets by a perusal of the ver" terse and uninformative remarks of the board. Here again the chief trouble is shortage of labour, and the high price of materials and the standing charges, owing to the heavy incoming water, are out of all proportion to the output. During the year under review, 26,486 tons of ore was milled (as against 32,419 tons in 1916) producing 458 tons of black tin, or an average recovery of 38·6 lb. per ton, a drop of 2·9 lb. against the previous year. Fortunately, this double drop in output and assay-value is mainly off-set by the higher price realized, or the financial position would ere now have been very serious; as it is, there is precious little margin between the liquid assets and liabilities. The inclusive operating cost has risen from 38s. 6d, to 46s. per ton, and of this, 15s. 11d. is for pumping charges, excluding repairs, One cannot but sympathize with a manager who has to handle a proposition with such a dead weight as this. According to the report, the stopes, at the time it was written, averaged 32·5 lb. per ton, although no lode widths are given, while the best development points appear to be the 340 fm. west and the 330 fm. east of Pascoe's shaft, which will average 40lb. per ton. The development footage was 1,766, or one foot for every 15 tons milled, so clearly exploration is not being neglected, even although the underground force has fallen from 208 to 153 men. It is a very short-sighted policy on the part of the Government to allow so important a tin-producer to be denuded of miners in this fashion. The directors have claimed no fees for the year, although the difficulties of the company must have demanded from them much more time and attention.

EXCESS PROFITS DUTY RECREATION SCHEMES.—It has now been decided by the Board of Inland Revenue that contributions of employers for recreative purposes will be allowable as an expense for the purposes of Excess Profits Duty, subject to the approval of the Government Department concerned, so that while the employer has full discretion in making a contribution, such contribution is in fact made by the Government, for the money would otherwise be payable as Excess Profits Duty. Recreation includes athletic and physical development, both outdoor and indoor, the provision of apparatus, playing fields, facilities for social intercourse, provision and furnishing of premises, and payment of a limited staff. In the Camborne-Redruth mining district, little or nothing has hitherto been done in the matter of the provision by the mining companies of facilities for physical exercise and social intercourse ; presumably, like the great majority of companies hitherto, they have not realized that money spent in this direction is well repaid, for it secures a healthier and more contented type of employee, whose physical and mental condition enables him to work to better advantage. In various parts of the country, notably Liverpool, Birmingham, and Glasgow, firms have combined to produce a recreation scheme applicable to the whole town or area, and there seems no reason why the mining companies and munition works in the Camborne-Redruth area should not combine to produce a suitable scheme which would be controlled by the representatives of both employers and employed. Recently it was intimated that the South Crofty company was providing cricket fields and football grounds for its employees, but no doubt the company would also support a general scheme.

EAST POOL & AGAR. — It is reported that a lode, either the Trevenson or Trembath has been located by diamond-drill 300 ft. north of the Rogers lode and that the core assayed 39 lb. black tin per ton. The width of the lode is stated to be 12 ft.

LABOUR ADVISORY COMMITTEE.—The close of the war and the return of large numbers of men will raise many difficult questions which ought to be thought out and prepared for in advance. The Cornish mining industry will be able to absorb a large number of men immediately at the termination of war, and an increasing number when capital is provided to start new undertakings. The Chamber of Mines might, therefore, usefully make inquiries to ascertain the number of men who could be absorbed by the existing undertakings, and after tabulating the information, hand it on to the Ministry of Labour through the Redruth Local Advisory Committee, which consists of employers and representatives of the various Trade Unions. Apparently, only one direct representative of mining sits on this committee, namely, Capt. R. A. Thomas, of Dolcoath, and seeing that tin mining is the principal industry of the district, one might have expected the Chamber to press for greater representation. However, it is obviously a matter of importance to have plans of this character made in advance, and it is certain that the industries which do so will have a distinct advantage, for the authorities will release first of all men who can return to a certain job.

TUNGSTEN AN ESSENTIAL INDUSTRY.—The interim report of the Government Committee on Commercial and Industrial Policy, known briefly as the Balfour Committee, has recently been issued, dealing with the preservation of essential industries after the war. Believing that tungsten is necessary for the safety of the nation, the committee recommends an export duty of £25 per ton on wolfram ore leaving the Empire, except when the Government refuses to purchase within fourteen days of the ore being offered. This is satisfactory in itself, but the committee does not appear to have considered the question of preserving and supporting the Cornish mining industry, which is now proving of great service and value to the nation, and, but for the short-sightedness of the Governments of the past, would have been able to supply tin, wolfram, and arsenic in much greater quantities, and to that extent the country would have been more self-supporting, a matter of great importance to an island country at war. This is another matter which the Chamber of Mines might tackle.

GEEVOR. — The Caunter lode has been intersected at the 7th level, 108 ft. south of the shaft, the lode being 2 ft. wide, and assaying 33 lb. black tin per ton. Should this lode open up satisfactorily as is anticipated, the tonnage for the mill will be considerably increased, and accordingly additional plant is being installed in anticipation.

PERSONAL.

SIR JOHN A. F. ASPINALL has been elected president of the Institution of Civil Engineers.

H. FOSTER BAIN has been visiting the Federated Malay States and Burma, and has returned to the United States, where he will be occupied with duties at the Bureau of Mines for the period of the war.

R. S. BOTSFORD has returned from Petrograd by way of Sweden and Norway, and is intending to go to Eastern Siberia via the United States.

A. F. BRIGHAM, formerly of the Jagersfontein, has been appointed manager of the Hollinger, at Porcupine.

E. H. BULMAN has been elected president of the South African Association of Mine Managers.

J. S. CURTIS is engaged in writing a history of the Rand. He invites other pioneers to help him with records. His address is Box 73, Johannesburg.

W. B. DOWLING has been elected president of the Canadian Mining Institute.

A. W. HOOKE is here from Nigeria.

C. J. INDER has returned from Nigeria.

HENRY I. KEEN, European manager for the Allis-Chalmers Co., has returned from the United States.

EDWARD S. KING, manager of the Waihi Grand Junction, is in London.

GEORGE PATCHIN, lecturer on metallurgy at the Sir John Cass Institute, has received a grant from the Carnegie Research Fund under the auspices of the Iron and Steel Institute to enable him to conduct a research on semi-steel and its heat treatment.

SIR H. ROSS SKINNER has returned to the Rand after being in England for three years.

DR. A. W. STICKNEY, lately of Kyshtim, is in London.

J. W. SUTHERLAND, manager of the Golden Horse-Shoe, has been elected president of the Australasian Institute of Mining Engineers.

J. B. TYRRELL was at Oklahoma in April.

LT.-COL. CAMPBELL N. WATSON, senior partner of H. A. Watson & Co., Metal Merchants, Liverpool, was seriously wounded last month.

CHARLES G. CRESSWELL died on March 23. He held the position of secretary of the Society of Chemical Industry for thirty years, being appointed in 1883, three years after the formation of the society, and retiring in 1916.

LIEUTENANT C. H. CUNNINGTON died on April 26 at his home in London after a severe illness contracted in France He was a member of the staff of the Geological Survey, and was attached to the Royal Engineers as geologist, serving in this capacity in the Dardanelles expedition and also in France.

ALFRED GORDON SALAMON, an Associate of the Royal School of Mines, well known as a consulting chemist, died last month. His name was identified with the process used by the British Cyanides Co. for extracting cyanides from coal gas.

MAJOR HAROLD WEBSTER, R.E., son of Mr. W. W. Webster, director of Minerals Separation Ltd., was killed on April 12, fighting on the Western Front. He was the inventor of an improvement in zinc distilling introduced at the Seaton Carew works of the Sulphide Corporation.

SIR JOHN WILLOUGHBY died on April 16 at the age of 59. For many years he had been identified with South Africa both as a soldier and as a pioneer of development. He was one of Dr. Jim's raiders and suffered ten months' imprisonment with his chief. He was one of the defenders of Ladysmith, and was one of the relievers of Mafeking. His last military service was in "German" East Africa. In Rhodesia his name was associated with Willoughby's Consolidated, which is engaged in agricultural and mining operations.

LIEUTENANT J. STONEMAN PRYOR, R.E., was killed at Bapaume on March 25. We have received the following notes of his career from one of his many friends. He was the eldest son of Mr. Joseph Pryor, of Saltash, Cornwall, formerly superintendent of the Balaghat mine, India, and of the Sao Bento mine, Brazil, and nephew of Mr. William Rich, formerly of Rio Tinto. On the completion of his course at the Camborne Mining School he obtained an appointment at the Sao Bento mine, in 1897, where he remained until the end of 1901. He then proceeded to the Esperanza copper mines, in the Province of Huelva, Spain, afterward passing to the employment of Messrs. F. C. Hills & Co. in the same district, and later was in charge of some prospecting work in Portugal. About the end of 1905, he accepted an appointment at the Famatina mines in the Argentine. Two years later he went to the Los Bayos mines in the same district, where he remained a year or two, after which he took up general practice, making Cordoba in the Argentine his headquarters. In 1916, he returned to England to offer his services to his country. Joining the Glamorgan Fortress Engineers after his military training was completed, he was employed on engineering work in this country until June of last year, when he was sent to France, where he performed good service for which he was recommended for the Croix de Guerre. Early in November he was transferred to Italy, where he also performed notable services, for which he was recommended for the Military Cross. He remained in Italy until within a few days of his death in France on March 25. This occurred near Bapaume, where he was posted with his men holding a railway embankment against overwhelming odds. Although owing to his almost continuous residence abroad he was not very widely known to the profession, by those who knew him he was recognized as being unusually capable, and as possessing an untiring zeal and thoroughness in carrying out his work. These characteristics brought him very quickly to the notice of his senior officers in the army, both in this country and in France and Italy. His age was 38. This is the second son that Mr. Pryor has lost in the war, the youngest having been posted as missing, and not subsequently heard of, comparatively early in the war. The only remaining son is Major T. Pryor, R E., who is with the Forces in Mesopotamia, being on leave from the Ooregum mine.

TRADE PARAGRAPHS

DAVID ROWELL & CO., LTD., of 14, Howick Place, Westminster, have issued a catalogue relating to their sectionalized buildings, constructed of wood or steel, or both.

THE PARKER RUST-PROOF CO., of Detroit, U.S.A., have introduced a method of protecting iron and steel surfaces by treating with a solution of acid meta-phosphate of iron, tungsten, molybdenum, or strontium.

A STOBIE electric steel furnace has been ordered by Armstrong, Whitworth & Co. These furnaces are the invention of Victor Stobie and have been successfully developed at Dunston, near Newcastle-on-Tyne, by the Stobie Steel Company.

THE YUBA CONSTRUCTION CO., of Marysville, California, send us several bulletins describing the work of the Yuba caterpillar tractor, which is extensively used for ordinary haulage, for road making, and for ploughing.

THE "LABOR SAVER" is the monthly organ of the Stephens-Adamson Manufacturing Co., of Aurora, Illinois, and makes a specialty of conveyors and elevators. The February issue contains an article describing ore-handling methods at the Inspiration mill.

THE METAL AND THERMIT CORPORATION has been formed at New York to amalgamate the two American companies, the Goldschmidt De-tinning Co. and the Goldschmidt Thermit Co. It is stated that the de-tinning company treats 100,000 tons of tin scrap yearly.

THE OUGHTIBRIDGE SILICA FIREBRICK CO., LTD., has been formed at Sheffield to extend the business of the Silica Firebrick Co. The shares are held by leading Sheffield steel firms, namely, Edgar Allen, Hadfields, Firths, Vickers, Cammell Laird, and John Brown.

THE BUCYRUS CO., of South Milwaukee, U.S.A., send us their general catalogue No 17, describing steam and electric shovels, dredges, and drag-line excavators. As recorded already in our pages this company has supplied bucket-dredges for Siberia, Burma, Siam, Federated Malay States, Portuguese East Africa, Nigeria, and Colombia.

THE SULLIVAN MACHINERY CO., of Chicago, are introducing a cutter-bit sharpener and general-utility forging hammer, operated by compressed air. It was originally designed for use in connection with the "Ironclad" coal-cutter. By substituting ordinary forging dies for the special cutter-bit dies, a great variety of ordinary forge and blacksmith work can be done.

METAL MARKETS

COPPER. — There has been no change in official prices. The agitation for an increase in the basis price to 25c. in America for electrolytic still continues. A conference on the subject is reported to have taken place at Washington, but it is not clear that the increase of 1½ c. will be granted. Inquiries are being received for delivery after June 1, when the existing arrangement will expire, but refiners are apparently disinclined to sell ahead, in the hope that the price will be advanced. The smelters' output for 1918 is estimated as 23,000 to 25,000 tons monthly as against 20,000 tons for 1917, but costs are higher now than when the price of 23½ c. was fixed, and to keep output at top figure the higher selling price is stated to be necessary. Apparently there is plenty of metal to supply private consumers in addition to Government needs, although some domestic consumers report a difficulty in obtaining prompt delivery. There is an increased consumption of scrap which can be purchased under the jobbing price of refined, and this accounts for a decrease in the output of casting copper made from scrap, and for an increase in the selling price of the latter. The difficulty of transport has been in great measure removed, and as a consequence deliveries have improved.

Average prices of cash standard copper: April 1918, £110. 5s; March 1918, £110. 5s.; April 1917, £134. 1s. 10d.

TIN. — A sensational advance to £380 has taken place in this metal in spite of the partial control exercised by the Metal Exchange. In consequence a closer supervision has been instituted by the Ministry of Munitions, and a system of rationing improvised under a Director of Tin Supplies, by whom sales of Straits to abroad have been prohibited and exports are being drastically curtailed, with a view of conserving the finer qualities for use in this country. Nevertheless the upward movement has continued, brought about partly by the competition of buyers in the East and partly by an embargo placed on Java shipments by the Dutch Government. The latter has now been removed so far as America is concerned. One result of the restrictions in dealing is that an enormous premium has been established in English tin, for which licences are more readily given than for Straits, and in which there is accordingly a much freer market. Most English smelters are sold out well ahead.

Average prices of cash standard tin: Apr £329. 18s. 1d.; March 1918, £318. 15s.; April 1917, £220. 3s. 10d.

LEAD —There is still no change in the official price in this country. Quotations are £29. 10s. to £28. 10s. net, or £30. 10s. 5d. to £29. 9s. 9d. gross. In America quotations have fluctuated considerably, the final price being 7·12½ cents.

Average prices of soft foreign lead: April 1918, £29; March 1918, £29; April 1917, £30.

SPELTER.—The official quotation still stands at £54 –£50, and there is not much business for common grades. The American market has been easier and prices are reduced from 7c. for spot to 6·75c. The latest prices for forward are 6·80c. June and 6·87½c. July. Forward sellers are inclined to be stiffening in their demands.

Average price of good ordinary brands: April 1918, £52; March 1918, £52; April 1917, £52. 18s. 11d.

ALUMINIUM.—£225 per ton. NICKEL.—£230 per ton.

ANTIMONY. — English regulus £85 per ton; crude £43 per ton; ore 10s. per unit.

QUICKSILVER.—£22. 10s. per flask of 75 lb.

BISMUTH.—12s. 6d. per lb. CADMIUM.—8s. per lb.

PLATINUM.—New 400s. per oz.; scrap 360s.

MOLYBDENITE.—105s. per unit, 90% MoS_2.

TUNGSTEN.—Ores 70% WO_3, 60s. per unit; tungsten powder, 6s. 8d. per lb.; ferro-tungsten 6s. 2d. per lb.

SILVER. — The American Government has undertaken to buy silver at one dollar per oz. fine, as foreshadowed last month, but the amount to be released for the market from its store of silver dollars is $350,000,000, not 250,000,000 as expected. Shipments are already being made direct to India on an extensive scale, 150,000,000 oz. being contracted for. The price in London is 49¼d. per oz. standard, which includes shipping charges.

PRICES OF CHEMICALS May 10

Owing to the war, buyers outside the controlled firms have a difficulty in securing supplies of many chemicals, and the prices they pay are often much higher than those quoted below.

		£	s.	d.
Alum	per ton	18	10	0
Alumina, Sulphate of	,,	18	10	0
Ammonia, Anhydrous	per lb.		1	10
,, 0·880 solution	per ton	34	0	0
,, Chloride of, grey	per cwt.	2	7	0
,, ,, ,, pure	,,	4	0	0
,, Nitrate of	per ton	75	0	0
,, Phosphate of	,,	125	0	0
,, Sulphate of	,,	17	10	0
Arsenic, White	,,	120	0	0
Barium Sulphate	,,	9	0	0
Bleaching Powder, 35% Cl.	,,	14	0	0
Borax	,,	42	0	0
Copper, Sulphate of	,,	67	0	0
Cyanide of Sodium, 100%	per lb.		1	0
Hydrofluoric Acid	,,			7
Iodine	,,		14	0
Iron, Sulphate of	per ton	17	0	0
Lead, Acetate of, white	,,	160	0	0
,, Nitrate of	,,	65	0	0
,, Oxide of, Litharge	,,	42	0	0
,, White	,,	46	0	0
Magnesite, Calcined	,,	14	0	0
Magnesium Sulphate	,,	12	0	0
Phosphoric Acid	per lb.		1	4
Potassium Carbonate	per ton	200	0	0
,, Chlorate	per lb.		2	3
,, Chloride 80%	per ton	55	0	0
,, Hydrate, (Caustic) 90%	,,	400	0	0
,, Nitrate	,,	70	0	0
,, Permanganate	per lb		13	0
,, Prussiate, Yellow	,,		3	6
,, Sulphate, 90%	per ton	60	0	0
Sodium Metal	per lb.		1	8
,, Acetate	per ton	125	0	0
,, Bicarbonate	,,	8	10	0
,, Carbonate (Soda Ash)	,,	7	0	0
,, ,, (Crystals)	,,	4	5	0
,, Hydrate, 76%	,,	26	0	0
,, Hyposulphite	,,	52	0	0
,, Nitrate, 95%	,,	27	0	0
,, Phosphate	,,	65	0	0
,, Silicate	,,	11	0	0
,, Sulphate (Salt-cake)	,,	2	12	6
,, ,, (Glauber's Salts)	,,	4	0	0
,, Sulphide	,,	37	0	0
Sulphur, Roll	,,	21	0	0
,, Flowers	,,	23	0	0
Sulphuric Acid, non-arsenical 144°T.	,,	4	5	0
,, non-arsenical 95%	,,	7	0	0
Superphosphate of Lime, 18%	,,	5	0	0

STATISTICS.

PRODUCTION OF GOLD IN THE TRANSVAAL.

	Rand	Elsewhere	Total	Value
	Oz.	Oz.	Oz.	£
Year 1912	8,753,563	370,731	9,124,299	38,757,560
Year 1913	8,430,998	363,826	8,794,824	37,358,040
Year 1914	8,033,567	344,570	8,378,139	35,588,075
Year 1915	8,772,919	320,752	9,073,671	38,627,461
Year 1916	8,971,359	324,179	9,295,538	39,484,934
January 1917	756,997	25,637	782,634	3,324,418
February	696,955	24,366	721,321	3,063,976
March	760,598	26,496	787,094	3,343,363
April	717,598	25,180	742,778	3,155,121
May	753,531	26,034	779,385	3,310,618
June	732,799	26,925	759,724	3,227,101
July	731,848	25,991	757,839	3,219,094
August	731,405	25,253	756,658	3,214,079
September	712,881	25,350	738,231	3,135,807
October	724,846	26,444	751,290	3,191,279
November	698,271	24,568	722,839	3,070 426
December	697,137	25,282	722,419	3,068,639
Year 1917	8,714.866	307,527	9,022,493	38,323,921
January, 1918	694,121	19,991	714,182	3,033,653
February	637,571	22,188	659,759	2,802,477
March	677,008	19,273	696,281	2,957,614

NATIVES EMPLOYED IN THE TRANSVAAL MINES.

	Gold mines	Coal mines	Diamond mines	Total
January 31, 1917	188,624	11,611	5,591	205,826
February 28	191,095	11,568	6,268	208,931
March 31	190,028	11,494	6,620	208,142
April 30	185,975	11,435	6,314	203,724
May 31	180,168	11,432	5,805	197,405
June 30	175,727	11,258	5,369	192,354
July 31	171,653	11,381	5,223	188,257
August 31	170,817	11,401	5,028	187,246
September 30	171,334	11,601	4,791	187,726
October 31	170,531	11,841	4,620	186,792
November 30	169,083	11,633	4,620	185,336
December 31	172,740	11,695	4,593	189,028
January 31, 1918	176,424	11,469	4,715	192,608
February 28	181,066	11,243	4,825	197,134
March 31	183,055	11,076	4,745	198,876

COST AND PROFIT ON THE RAND.

Compiled from official statistics published by the Transvaal Chamber of Mines. The profit available for dividends is about 60% of the working profit.

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
January 1917	2,337,066	26 10	18 8	7 11	941,520
February	2,153,691	27 3	19 2	7 10	841,259
March	2,430,590	26 7	19 0	7 4	879,351
April	2,235,833	27 2	19 2	7 8	857,710
May	2,405,855	26 4	18 7	7 5	887,527
June	2,288,426	26 11	19 2	7 7	867,639
July	2,294,668	26 11	19 0	7 7	869,577
August	2,301,892	26 9	19 0	7 6	859,517
September	2,195,884	27 5	19 4	7 9	848,096
October	2,280,461	26 10	19 5	7 2	814,211
November	2,156,814	27 4	19 11	7 2	775,502
December	2,130,510	27 7	20 0	7 4	783,729
January, 1918	2,167,411	27 1	20 7	6 4	703,665

PRODUCTION OF GOLD IN RHODESIA AND WEST AFRICA.

	RHODESIA.		WEST AFRICA.	
	1917	1918	1917	1918
	£	£	£	£
January	296,113	253,807	131,665	107,863
February	289,734	232,023	104,892	112,865
March	300,183	230,023	158,727	112,605
April	297,977	—	123,825	—
May	299,271	—	121,104	—
June	302,195	—	114,489	—
July	288,731	—	142,017	—
August	294,359	—	130,278	—
September	291,367	—	127,168	—
October	289,978	—	126,295	—
November	275,829	—	126,915	—
December	270,616	—	122,602	—
Total	3,495,391	715,853	1,529,977	333,333

WEST AUSTRALIAN GOLD STATISTICS.

	Reported for Export oz.	Delivered to Mint oz.	Total oz.	Total value £
January 1917	*	83,962	*	*
February	*	81,810	*	*
March	*	76,171	*	*
April	*	82,144	*	*
May	*	78,165	*	*
June	*	82,600	*	*
July	*	81,166	*	*
August	*	80,181	*	*
September	*	81,761	*	*
October	*	73.901	*	*
November	*	80,642	*	*
December	*	78,793	*	*
January, 1918	*	73,703	*	*
February	*	76,987	*	*
March	*	69 730	*	*
April	*	66,079	*	*

* By direction of the Federal Government the export figures will not be published until further notice.

The total yield at the mines for 1917 is reported at 973,316 oz.

AUSTRALIAN GOLD RETURNS.

	VICTORIA.		QUEENSLAND.		NEW SOUTH WALES	
	1917	1918	1917	1918	1917	1918
	£	£	£	£	£	£
January	67,627	32,134	50,150	47,600	29,000	25,000
February	65,450	—	63,200	45,470	26,000	28,000
March	74,794	—	61,200	48,020	41,000	30,000
April	75,139	—	62,470	—	21,000	—
May	65,623	—	65,450	—	28,400	—
June	64,180	—	73,100	—	24,600	—
July	68,937	—	71,820	—	44,000	—
August	101,428	—	74,800	—	21,000	—
September	61,701	—	64,180	—	20,000	—
October	33,533	—	54,400	—	47,000	—
November	75,912	—	42,380	—	29,000	—
December	56,967	—	64,170	—	19,000	—
Total	846,540	32,134	744,537	141,090	349,000	83,000

PRODUCTION OF GOLD IN INDIA.

	1915	1916	1917	1918
	£	£	£	£
January	201,255	192,150	190,047	176,030
February	195,970	183,264	180,904	173,343
March	194,350	186,475	189,618	177,950
April	196,747	192,208	185,835	—
May	199,786	193,604	184,874	—
June	197,447	192,469	182,426	—
July	197,056	191,404	179,660	—
August	197,984	192,784	181,005	—
September	195,952	192,330	183,630	—
October	195,531	191,502	182,924	—
November	192,714	192,298	182,388	—
December	204,590	205,164	190,852	—
Total	2,369,382	2,305,652	2,214,163	527,323

DAILY LONDON METAL PRICES

Copper, Lead, Zinc, Tin, in £ per long ton. Silver in pence per standard ounce.

	Copper Standard	Copper Electrolytic	Copper Best Select'd	Soft For'n Lead	Zinc	Tin Standard	Silver
April	£	£	£	£ s.	£ s.	£ s. d.	d.
11	110	125	123	29 10	54 0	322 0 0	46¼
12	110	125	123	29 10	54 0	322 0 0	46¼
15	110	125	123	29 10	54 0	322 0 0	47
16	110	125	123	29 10	54 0	322 0 0	47¼
17	110	125	123	29 10	54 0	327 0 0	47¼
18	110	125	123	29 10	54 0	330 0 0	47¼
19	110	125	123	29 10	54 0	330 0 0	47¾
22	110	125	123	29 10	54 0	333 0 0	49
23	110	125	123	29 10	54 0	343 0 0	49
24	110	125	123	29 10	54 0	343 0 0	49¼
25	110	125	123	29 10	54 0	350 0 0	49¼
26	110	125	123	29 10	54 0	350 0 0	49¼
29	110	125	123	29 10	54 0	350 0 0	49¼
30	110	125	123	29 10	54 0	360 0 0	49¼
May							
1	110	125	123	29 10	54 0	360 0 0	49¼
2	110	125	123	29 10	54 0	360 0 0	49⅛
3	110	125	123	29 10	54 0	360 0 0	49⅛
6	110	125	123	29 10	54 0	380 0 0	49⅛
7	110	125	123	29 10	54 0	380 0 0	49⅛
8	110	125	123	29 10	54 0	380 0 0	49⅛
9	110	125	123	29 10	54 0	380 0 0	49⅛
10	110	125	123	29 10	54 0	380 0 0	49⅛

Imports of Ores and Metals into United Kingdom.

These figures now include Government imports.

* Statistics not published. Long tons.

	Year 1917	Mar. 1918	Year 1918
	Tons	Tons	Tons
Iron Ore	*	*	*
Copper Ore	*	*	*
,, Matte and Precipitate	28,241	1,168	5,494
,, Metal	142,778	19,203	52,736
Copper and Iron Pyrite	*	*	*
Tin Concentrate	*	*	*
,, Metal	27,143	123	3,967
Manganese Ore	*	*	*
Lead, Pig and Sheet	147,124	16,231	58,069
Zinc (spelter)	76,105	7,030	21,376
	lb.	lb.	lb.
Quicksilver	2,172,434	380	304,655

Exports of Copper from United States

1917	Long tons	1917	Long tons	1918	Long tons
January	25,540	July	38,127	January	40,530
February	21,937	August	45,304	February	28,160
March	51,246	September	30,493	March	22,550
April	79,001	October	39,115	April	—
May	45,241	November	38,638	May	—
June	39,816	December	35,000	June	—
Total	265,783	Total 1917	484,120	Total 1918	91,240

Outputs of Tin Mining Companies.

In Tons of Concentrate.

	Year 1917	Mar. 1918	Year 1918
	Tons	Tons	Tons
Bisichi (Nigeria)	278	30	90
Briseis (Tasmania)	237	29	88
Dolcoath (Cornwall)	863	66	202
East Pool (Cornwall)*	1,012	102	296
Gopeng (F.M.S.)	1,039	77	229
Malayan Tin (F.M.S.)	828	60	169
Mongu (Nigeria)	571	50	135
Naraguta (Nigeria)	503	54	146
N. N. Bauchi (Nigeria)	550	50	145
Pahang (F.M.S.)	2,612	161	492
Rayfield (Nigeria)	660	65	195
Renong (Siam)	1,023	84	214
Siamese Tin (Siam)	808	105	326
South Crofty (Cornwall)*	694	48	163
Tekka-Taiping (F.M.S.)	422	29	71
Tongkah Harbour (Siam)	1,229	61	266
Tronoh (F.M.S.)	1,046	100	300

* Including Wolfram.

Stocks of Tin.

Reported by A. Strauss & Co. Long tons.

	Feb. 28, 1918	March 31, 1918	April 30, 1918
	Tons	Tons	Tons
Straits and Australian, Spot	2,228	1,190	1,604
Ditto, Landing and in Transit	475	—	325
Other Standard, Spot and Landing	482	438	464
Straits, Afloat	*3,370	*5,000	*5,575
Australian, Afloat	—	—	—
Banca, on Warrants	—	—	—
Ditto, Afloat	*2,900	*3,655	*3,655
Billiton, Spot	—	—	—
Ditto, Afloat	*300	*300	*300
Straits, Spot in Holland and Hamburg	—	—	—
Ditto, Afloat to Continent	*500	*500	*500
Afloat for United States	*9,555	*9,246	*7,246
Stock in America	197	134	64
Total Stock	20,007	20,463	19,733

* Estimated.

Shipments and Imports of Tin

Reported by A. Strauss & Co. Long tons.

	Year 1916	Year 1917	April 1918	Year 1918
	Tons	Tons	Tons	Tons
Shipments from:				
Straits to U.K.	27,157	28,099	*2,500	*7,500
Straits to America	25,943	24,977	*2,500	*11,000
Straits to Continent	8,487	9,290	—	*1,150
Australia to U.K.	2,537	349	—	—
U.K. to America	14,863	12,890	50	858
Imports of Bolivian Tin into Europe	15,116	19,209	1,408	4,639
Deliveries in U.K.	16,862	15,142	1,022	5,738
,, ,, Holland	943	1,714	—	*71

* Estimated.

Nigerian Tin Production.

In long tons of concentrate of unspecified content.

Note. These figures are taken from the monthly returns made by individual companies reporting in London, and probably represent 85% of the actual outputs.

	1913	1914	1915	1916	1917	1918
	Tons	Tons	Tons	Tons	Tons	Tons
January	466	485	417	531	667	666
February	427	469	358	528	646	653
March	510	502	418	547	655	663
April	430	482	444	486	555	—
May	360	480	357	536	509	—
June	321	460	373	510	473	—
July	357	432	455	506	479	—
August	406	228	438	498	551	—
September	422	289	442	535	538	—
October	480	272	511	584	578	—
November	445	283	467	679	621	—
December	478	326	533	654	655	—
Total	5,103	4,708	5,213	6,594	6,927	1,982

Production of Tin in Federated Malay States.

Estimated at 70% of Concentrate shipped to Smelters. Long Tons. No figures published since June, 1917.

	1913	1914	1915	1916	1917
	Tons	Tons	Tons	Tons	Tons
January	4,121	4,983	4,395	4,316	3,558
February	3,823	3,555	3,780	3,372	2,755
March	3,562	3,839	3,653	3,696	3,286
April	4,066	4,087	3,619	3,177	3,251
May	4,319	4,135	3,823	3,729	3,413
June	3,993	4,303	4,048	3,435	3,489
July	4,245	4,582	3,544	3,517	...
August	4,620	3,591	4,046	3,732	...
September	4,379	3,623	3,932	3,636	...
October	4,409	3,908	3,797	3,681	...
November	3,976	4,085	4,059	3,635	...
December	4,614	4,351	4,071	3,945	...
	50,127	49,042	46,767	43,871	19,752

Sale of Tin Concentrate at Redruth Ticketings.

	Long tons	Value	Average
July 2, 1917	159½	£21,661	£135 16 1
July 16	144½	£18,896	£130 19 11
July 30	168	£23,225	£138 5 0
August 13	160¼	£21,757	£135 15 4
August 27	156½	£21,429	£136 18 6
September 10	160¼	£21,784	£135 18 9
September 24	153	£21,448	£140 3 9
October 8	160½	£22,160	£138 11 6
October 22	153	£21,712	£141 18 2
November 6	144¼	£21,063	£146 0 5
November 19	156	£24,737	£158 11 6
December 3	148	£24,609	£165 5 6
December 17	148½	£25,620	£172 10 7
December 31	151¾	£23,450	£154 10 8
Total, 1917	4,186	£561,003	£134 0 0
January 14, 1918	141	£23,563	£167 2 3
January 28	171½	£28,976	£168 19 2
February 11	166½	£29,674	£178 4 6
February 25	156½	£28,213	£180 18 4
March 11	178¼	£33,398	£187 7 4
March 25	169½	£31,253	£184 7 9
April 8	157¼	£29,575	£188 1 8
April 22	159½	£31 402	£196 17 7

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS:	May 7, 1917 £ s. d.	May 7, 1918 £ s. d.
Rand:		
Bantjes	7 6	3 0
Brakpan	5 2 0	4 15 0
Central Mining (£8)	6 6 3	5 17 6
Cinderella	4 3	4 0
City & Suburban (£4)	1 13 9	18 9
City Deep	4 7 6	3 5 0
Consolidated Gold Fields	1 11 3	1 15 0
Consolidated Langlaagte	1 7 0	16 3
Consolidated Main Reef	17 0	15 9
Consolidated Mines Selection (10s.)	1 4 6	1 10 6
Crown Mines (10s.)	2 13 0	1 16 3
Daggafontein	13 6	1 8 9
D. Roodepoort Deep	11 3	9 9
East Rand Proprietary	11 0	4 6
Ferreira Deep	1 3 9	14 6
Geduld	2 2 6	1 19 6
Geldenhuis Deep	1 2 6	13 0
Gov't Gold Mining Areas	3 2 6	3 13 0
Heriot	2 2 6	1 1 3
Jupiter	6 6	5 0
Kleinfontein	1 3 6	17 9
Knight Central	9 6	3 0
Knight's Deep	1 0 0	8 0
Langlaagte Estate	16 6	13 6
Meyer & Charlton	5 6 3	4 16 3
Modderfontein (£4)	20 10 0	22 15 0
Modderfontein B	7 15 0	7 16 3
Modder Deep	7 6 3	7 8 9
Nourse	1 3 0	17 6
Rand Mines (5s.)	3 7 6	2 17 0
Rand Selection Corporation	3 15 0	4 15 0
Randfontein Central	13 9	11 6
Robinson (£5)	15 0	15 6
Robinson Deep A (1s.)	1 11 3	1 0 0
Rose Deep	1 0 6	18 3
Simmer & Jack	5 9	5 3
Simmer Deep	4 3	3 0
Springs	3 1 3	3 15 0
Sub-Nigel	1 7 6	1 6 3
Van Ryn	1 18 9	1 1 3
Van Ryn Deep	3 6 3	3 10 0
Village Deep	1 6 3	1 0 0
Village Main Reef	15 0	12 0
Witwatersrand (Knight's)	2 2 6	1 5 0
Witwatersrand Deep	16 6	7 9
Wolhuter	10 6	5 0
Other Transvaal Gold Mines:		
Glynn's Lydenburg	15 0	18 9
Sheba (5s.)	1 3	9
Transvaal Gold Mining Estates	17 0	16 0
Diamonds in South Africa:		
De Beers Deferred (£2 10s.)	13 5 0	12 17 6
Jagersfontein	4 7 6	4 2 6
Premier Deferred (2s. 6d.)	7 10 0	6 15 0
Rhodesia:		
Cam & Motor	8 6	11 0
Chartered British South Africa	12 6	16 0
Eldorado	8 6	6 9
Falcon	14 9	1 2 3
Gaika	8 6	18 9
Giant	5 6	7 0
Globe & Phœnix (5s.)	1 11 3	1 11 3
Lonely Reef	1 3 3	1 12 0
Rezende	1 1 3	4 2 6
Shamva	1 5 0	2 0 0
Wanderer (3s.)	2 0	1 0
Willoughby's (10s.)	5 6	5 0
West Africa:		
Abbontiakoon (10s.)	5 0	3 6
Abosso	9 6	7 6
Ashanti (4s.)	19 0	19 6
Prestea Block A	6 0	3 9
Taquah	17 6	15 6
West Australia:		
Associated Gold Mines	3 0	3 6
Associated Northern Blocks	2 9	2 6
Bullfinch	2 0	
Golden Horse-Shoe (£5)	2 1 3	2 2 6
Great Boulder Proprietary (2s.)	11 0	11 6
Great Boulder Perseverance	1 0	—
Great Fingall (10s.)	1 0	1 9
Ivanhoe (£5)	2 3 9	1 16 3
Kalgurli	8 9	9 0
Sons of Gwalia	14 0	9 0

GOLD, SILVER, *cont.*	May 7, 1917 £ s. d.	May 7, 1918 £ s. d.
Others in Australasia:		
Mount Boppy, New South Wales	6 0	7 6
Talisman, New Zealand	12 6	15 0
Waihi, New Zealand	1 14 9	1 15 0
Waihi Grand Junction, New Z'lnd	15 0	16 0
America:		
Alaska Treadwell (£5), Alaska	1 15 0	10 0
Buena Tierra, Mexico	10 0	12 6
Camp Bird, Colorado	7 0	8 6
Casey Cobalt, Ontario	6 0	9 0
El Oro, Mexico	9 0	9 0
Esperanza, Mexico	10 6	8 3
Frontino & Bolivia, Colombia	11 6	12 6
Le Roi No. 2 (£5), British Columbia	7 0	7 0
Mexico Mines of El Oro, Mexico	4 0 0	5 16 3
Oroville Dredging, California	15 3	19 0
Plymouth Consolidated, California	1 1 0	1 2 6
St. John del Rey, Brazil	16 0	16 0
Santa Gertrudis, Mexico	10 6	13 0
Tomboy, Colorado	19 3	17 9
Russia:		
Lena Goldfields	1 17 6	1 5 0
Orsk Priority	1 1 3	12 6
India:		
Champion Reef (2s. 6d.)	5 9	5 6
Mysore (10s.)	3 2 6	2 12 0
Nundydroog (10s.)	1 5 6	1 2 6
Ooregum (10s.)	19 6	19 6
COPPER:		
Arizona Copper (5s.), Arizona	2 8 0	2 7 6
Cape Copper (£2), Cape Province	4 2 [illegible]	2 15 0
Chillagoe (10s.), Queensland	3	1 0
Cordoba (5s.), Spain	3 0	2 6
Great Cobar (£5), N.S.W.	2 3	2 0
Hampden Cloncurry, Queensland	1 14 0	1 7 3
Kyshtim, Russia	2 7 6	17 6
Messina (5s.), Transvaal	10 0	8 0
Mount Elliott (£5), Queensland	5 7 6	3 10 0
Mount Lyell, Tasmania	1 7 0	1 7 9
Mount Morgan, Queensland	1 15 6	1 12 0
Rio Tinto (£5), Spain	62 10 0	66 10 0
Sissert, Russia	1 5 [illegible]	15 0
Spassky, Russia	1 17 6	17 6
Tanalyk, Russia	2 2 6	17 6
Tanganyika, Congo and Rhodesia	3 2 6	3 3 0
LEAD-ZINC:		
Broken Hill:		
Amalgamated Zinc	1 12 6	1 7 9
British Broken Hill	1 9 3	2 5 9
Broken Hill Proprietary (8s.)	2 7 0	3 8 0
Broken Hill Block 10 (£10)	1 3 9	1 15 0
Broken Hill North	2 10 0	3 1 3
Broken Hill South	8 5 0	10 10 0
Sulphide Corporation (15s.)	1 6 0	1 7 0
Zinc Corporation (10s.)	16 9	1 3 6
Asia:		
Burma Corporation	4 2 6	4 6 3
Irtysh Corporation	2 1 9	18 9
Russian Mining	1 0 0	7 6
Russo-Asiatic	4 18 9	2 1 3
TIN:		
Aramayo Francke, Bolivia	1 12 6	2 8 9
Bisichi, Nigeria	14 0	15 3
Briseis, Tasmania	4 9	[illegible] 0
Dolcoath, Cornwall	10 3	12 9
*East Pool, Cornwall	2 0 0	1 11 3
Ex-Lands Nigeria (2s.), Nigeria	[illegible] 0	2 9
Geevor (10s.) Cornwall	13 0	1 6 3
Gopeng, Malay	1 10 0	1 16 3
Ipoh Dredging, Malay	17 0	17 0
Malayan Tin Dredging, Malay	2 0 0	2 1 3
Mongu (10s.), Nigeria	15 0	16 3
Naraguta, Nigeria	15 0	17 6
N. N. Bauchi Pref. (10s.), Nigeria	9 9	12 6
Pahang Consolidated (5s.), Malay	11 3	12 6
Rayfield, Nigeria	8 0	14 9
Renong Dredging, Siam	2 5 0	2 5 0
Ropp (4s.), Nigeria	18 3	1 4 6
Siamese Tin, Siam	2 8 9	3 0 0
South Crofty (5s.), Cornwall	1 1 9	2 10 6
Tekka, Malay	3 0 0	3 15 0
Tekka-Taiping, Malay	2 17 6	3 15 0
Tronoh, Malay	1 7 6	1 13 9

* £1 shares split into 4 of 5s. each in August 1917.

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also reviews of new books, and abstracts of the yearly reports of mining companies.

THE UMTALI GOLD BELT, RHODESIA.

The Geological Survey of Southern Rhodesia has published a short report by A. E. V. Zealley on the geology and mineral deposits of the Umtali gold belt. This district is on the border of Portuguese East Africa, and the railway from Salisbury passes through it. The Rezende and Penhalonga mines are on the belt, and a number of new deposits have recently been staked.

The general geological structure is simple. Two enormous masses of granite occupy the country to the north and south of the schist belt. The edges of these masses are nearly parallel, and trend north-east by east from the confluence of the Sabi and Tsungwesi rivers through Odzi to the neighbourhood of Grand Reef. Onward to the frontier of Portuguese East Africa the edge of the southern granite trends eastward, while the edge of the northern granite becomes less regular and trends east-north-east. The belt of schists lying between the granite masses is thus fairly regular in the stretch of country between the Sabi river and Odzi, but it takes an easterly bend near Grand Reef, and expands considerably. On the Portuguese border the schist belt is nearly ten miles wide, at Grand Reef about three miles, and at Odzi less than two miles; but it dwindles more gradually toward the Sabi river, where it is only about a mile wide. The rocks of the schist belt are chiefly greenstone schists, among which serpentine, altered to amphibolite and to talcose schists, is dominant. These form the backbone of the belt in the form of the Christmas Pass Range and its continuation south-west of Odzi. Epidiorite and cleaved hornblendic and chloritic schists are common rock types. Felsites and porphyries become important members of the schist belt around Penhalonga. Sugary limestones and altered limestones containing silicates are present on the southern flank of the schist hills on both sides of the Tsungwesi river. No sedimentary conglomerates or banded ironstone are seen; but there are occasional small stretches of felsite, which, owing to secondary ferruginization and silicification, rather resemble banded ironstone. Pegmatite and greisen veins, and occasional lenses of granite, lie in the schists. Dolerite dykes of late geological age occur both in the schist and granite, and there are thin sills of dolerite in the granite around the Pilgrim mine. A narrow zone of serpentine, lying from two to three miles inside the southern granite, and parallel to its edge, appears to be a remarkably constant feature. It gives rise to a range of typical serpentine hills about half a mile wide near Umtali, but much narrower near the Sabi river. The gold deposits, which occur throughout the belt, are mainly in the schists; but between Odzi and the Sabi river a number of deposits have been worked in the granite.

The southern granite mass has a margin about two miles wide, which, almost wherever exposed, is gneissose, and forms flat, or, as in Umtali township, rolling ground free from kopjes. The northern mass similarly has a gneissic edge developed for stretches here and there, but it is less regular than the gneissic margin of the southern mass. Behind these gneissic belts, bold, picturesque granite hills rise to considerable heights above the general level. The granite country north of Penhalonga toward Inyanga is strikingly different from that to the west and south. It is high lying, short-grassed, comparatively treeless, undulating country, supporting numerous perennial streams. Wherever examined, the granite of the undulating ground was found to be biotite granite in which the mica has a parallel orientation, that is, a feeble gneissic structure.

Many of the mineral deposits in the belt consist of lodes of highly argentiferous, but only slightly auriferous sulphides, with or without quartz gangue; the most abundant sulphides being galena, arsenopyrite, and chalcopyrite, which are exemplified respectively by the lodes of the Clutha, Bessie, and Umtali Copper mines. Other types are "schist reefs," or replacement deposits, either rich in sulphide such as the Virginia, or poor in sulphides such as the Kenya and Toronto; gold-quartz veins with normal small amounts of sulphide such as the Rezende, Snipe, and Odzi, which are common; and the special type of "schist reef" nearly free from sulphides, exemplified by the Pilgrim, Monte Carlo, and Quagga. The gold-quartz veins commonly contain the sulphides mentioned together with pyrrhotite, pyrite, and blende; while bismuth sulphide is an important constituent of a quartz vein recently discovered, and bismuth carbonate occurs in the outcrops of several other reefs (Curlew, Quarry, etc.). Crocoite (lead chromate) is a characteristic mineral in several reefs (Penhalonga, Kenya, etc.); fine specimens of this uncommon mineral have been found in the Penhalonga. Small quantities of nickel minerals are present in the gossans of the sulphide lodes around Odzi, and nickel occurs in the pyrrhotite of several of the mines around Kenya Hill and elsewhere. Cobalt has also been detected.

A deposit of white amphibole asbestos occurring in pockets in a wide fissure in the narrow serpentine zone in the southern granite is being opened up at the Sabi river. A small development of chrysotile asbestos is visible here and there in this serpentine body, but as yet no deposit of commercial value has been located. A copper deposit on the southern boundary of Craigendoran farm, Odzi, is said to lie in the serpentine. Small bodies of magnesite occur around the Pilgrim mine, but none are sufficiently large to be of economic importance. The mica prospected some years ago in the altered pegmatites between Odzi and Tsungwesi was found to be lithia mica. This is unsuitable for the uses to which mica sheets are put in the industries, primarily because of its easy fusibility.

The lithia greisens of Odzi Reserve and the Tsungwesi river have recently been prospected, with the result that tin, tantalum, and tungsten minerals have been found. The greisens seem to be a feature of the southern granite mass. They occur in at least three places between Odzi Reserve and the Sabi river, and they have been recorded from the southern edge of this granite mass on the Wengesi river, Melsetter. The wash in the neighbourhood of the greisens in the Odzi Reserve affords concentrates containing tinstone and


GEOLOGICAL SURVEY OF SOUTHERN RHODESIA
SKETCH MAP
OF THE
UMTALI MINERAL BELT
Scale of Miles
5 4 3 2 1 0 5 10 15 20
By A.E.V.Zealley, A.R.C.S.
True North.
PORTUGUESE
EAST
AFRICA
UMTALI
Penhalonga
Old Umtali
Umtali River
Odzi River
Odzi
Malenje
Mt Mapema
Sabi River
Sakubva River
Odzani River
Lesapi River
FROM SALISBURY
TO NELSETTER
EXPLANATION
D Dolerite
F Felsite and Porphyry
G Granite
G Gneissic granite
S Serpentine
B Greenstone
Mine
House
Beacon
3552 Height in feet above sea level
Chief Roads
Railway
Dip of Foliation, amount in degrees
Strike of vertical foliation
Approximate boundaries of granite
Outcrop of lode, amount of dip in degrees
Outcrop of lode, vertical

tantalite, while a second tantalum mineral, microlite (tantalate of lime), forming small aggregates of yellowish green resinous-lustred grains, was detected by panning certain of the greisens.

The ultra-acid portions of the granite lying along the edge, or a short distance inside the gneissic margin of the southern granite mass, between Odzi and the Sabi river, probably form long lenses oriented parallel with the edge of the granite. They are composed almost entirely of coarse granular quartz, but generally a small amount of pearly white mica is visible. They are partly massive and unsheared, but commonly cleaved and rodded, and have thus come to be called quartzites and mica schists. In most instances they form rising ground or even kopjes. The granite which this rock lies in is more or less gneissose biotite granite, here and there porphyritic and pegmatitic. Each occurrence of ultra-acid granite noted supports, or has supported gold-mining operations; the Pilgrim, Quagga, Monte Carlo, Snipe Extension (Curlew), and probably the Surrey, Grand Manica, and several other reefs in their neighbourhood are examples. Although vein quartz is present in each of these in the form of blebs, strings, or fairly well-defined veins, mining operations show that the gold is by no means confined to the vein quartz, but is distributed through irregular patches of the ultra-acid granite undefined by any structure such as fissure walls or joints. The ore-bodies may thus be large, but they are low-grade, and there seems to be sufficient evidence to justify the general conclusion that below water-level the rock becomes unprofitable. No sulphide is present beyond traces of pyrite and galena, but in the Snipe Extension body, which has numerous ancient workings on it, pale yellow and greenish bismuth carbonate is abundant, and points to the presence of bismuth sulphide. The Pilgrim ore-body is said to have no ancient workings on it, yet it formed a conspicuous outcrop of rich ore with a great deal of rubble. Well-defined pegmatite veins are numerous in the mine, and cut across the ore.

The exploitation of the arsenopyrite and galena ores is hindered by certain difficulties. Although well-defined big lodes containing both silver and gold are proved, such as the Bessie, with its 2,000 ft. strike and average width of 3 to 4 ft.; the Champion and Cairn Dhu arsenopyrite lodes; the Virginia, a virgin lode 2½ to 11 ft. wide, and stoped to surface over 360 ft.; the Clutha, consisting of several large quartz veins rich in pockets of galena mixed with blende, arsenopyrite, and cupriferous pyrite; yet, because the percentage of silver and gold contained in the sulphide bodies is generally insufficient to justify the installation of individual reduction plants on these mines, the sulphide zone is not worked. The weathered zones of several of these lodes have been skilfully mined and treated for their silver and gold. But when all that can be safely mined is abstracted, the plants are shifted to other properties. No central treatment plants exist at present for the roasting of arsenopyrite and the smelting of galena, with the main object of recovering the base metals, and at present these ores or their concentrates are not sent to the Union for treatment, although there are chances that under the present reduced transport charges this procedure might be adopted. The only other alternative, namely, shipping concentrates for treatment abroad, has been tried, but was found unprofitable at the time. Since this report was written, it is understood that plans are being made to treat the arsenical ores locally for the recovery of white arsenic and the manufacture of sodium arsenite for cattle dips.

These facts constitute severe restrictions upon the activities of small workers and prospectors, as is evidenced by the fact that only a few of the known lead deposits have had any prospecting or development work done on them; and there is but small incentive to prospect for others. The galena concentrate of the Penhalonga was exported for treatment abroad for some years; but other sulphide concentrates, and hundreds of tons of sulphide ore, are lying in dumps at the mines; while, as already mentioned, the system now in vogue is to leave such ore in the mines by selective mining, a method both costly and wasteful, but for which the workers cannot be blamed. The chalcopyrite ores in the district are being mined and sent by rail to the Falcon mine, Umvuma, for customs treatment.

THE NATURAL SODA DEPOSIT IN THE TRANSVAAL.

Brief notices have been given in our pages of the deposit of carbonate of soda north of Pretoria, but full technical details have so far been unavailable in this country, though Hatch & Corstorphine refer to it in their Geology of South Africa, and H. Kynaston some years ago wrote a short memoir for the Geological Survey of South Africa. In his presidential address to the Geological Society of South Africa last year, Dr. Percy A. Wagner gave an account of the deposit. The full report of his address has only just arrived in this country, and we reproduce herewith his reference to the deposit. The South African Alkali Company is working the deposit to considerable profit.

The establishment of a successful soda industry at the "salt pan" situated on the farm Zoutpan, No. 467, in the southern portion of the Bushveld, has drawn the attention of geologists once more to that unusual deposit, and has revived the controversy regarding its nature and origin. The pan is a remarkable, flat-bottomed, crater-like depression within a circular rim of red granite, which rises in the form of a low range of bush-clad hills from a monotonous expanse of gently undulating tree-steppe, about 25 miles north-north-west of Pretoria. The granite rim at its highest point has an elevation of about 260 ft. above the floor of the pan, which lies fully 150 ft. below the general level of the surrounding country, the descent being steep and abrupt, in contrast to the gentle slopes on the outer side of the rim. Cohen, who made a geological examination of the pan in 1873, was the first to call attention to the close resemblance that it bears to the explosion craters of the Eifel, which is so striking that the complete absence in, and in the neighbourhood of, the depression of all vestiges of lava or pyroclastic material evokes the surprise of every geologist visiting the locality. The upper portion of the crater walls consists of coarse-grained red granite, in which occasional bands of granite porphyry and micro-granite were noted by Kynaston. The lower slopes, down to the salt-encrusted margins of the actual salt pan, are formed of granite detritus.

In its original condition, as Cohen and others saw it, the pan-bottom was during the rainy season covered to a depth of a few feet with water, or, more correctly speaking, brine. This evaporated during the succeeding dry months, leaving first the margins and then the whole of the pan-bottom covered with a dazzling white incrustation of crystallized saline matter, composed, according to Cohen, of cubical crystals of common salt with some trona and small quantities of calcite. By the serial evaporation of solutions obtained by redissolving this material in fresh water in iron tanks, salt of fairly good quality was for many years manufactured by farmers residing in the neighbourhood of the pan. The surface crust, which has long since been removed, is underlain by alternations of layers of dark mud and crystalline trona containing a variable proportion of sodium chloride. A bore-hole, put down some years ago near the centre of the pan, passed through five distinct trona layers, apparently all within 29 ft. of the surface. Below these it entered muds and clays that continued until a depth of 188 ft. was reached, at which depth boring was stopped. The trona beds range in thickness from 1 ft. 6 in. to 8 ft. 6 in. Whether they are continuous right across the pan is not clear.

At the time of Dr. Wagner's visit in February, 1916, the uppermost layer was in process of systematic removal, and could be studied in section in the workings in the bottom of the pan. It was everywhere seen to be underlain by a deposit of dark sticky mud, and all the deeper excavations were filled with brine of deep brownish-red colour.

The trona layer has a thickness of from 12 to 20 inches, and is composed of interlocking radial aggregates of pale-brownish, blade-like crystals. Judging by its appearance, and also by such analyses as have been made, the material is variable in composition. An exceptionally pure specimen was analysed by Mr. J. Whitby, of Messrs. Littlejohn & Whitby, with the following result: Na_2CO_3 42·9%, $NaHCO_3$ 38·6%, $NaCl$ 0·6%, H_2O 19·6%, total 101·7%. These figures approximate very closely to the theoretical composition of trona, namely, Na_2CO_3, $NaHCO_3$, $2H_2O$. As a rule the crude trona contains appreciable quantities of organic matter, sodium chloride, and insoluble matter.

With a view to getting rid of the bulk of the soluble impurities and of the water of crystallization, it is first washed with fresh water and then calcined at a fairly high temperature in reverberatory furnaces. An average sample of the calcined material was found by Messrs. Littlejohn & Whitby to have the following composition: Na_2CO_3 96·46%, $NaCl$ 1·30%, Na_2SO_4 0·18%, CaO trace, MgO trace, K_2O trace, SiO_2 and insoluble 0·50%, MnO_2 nil, insoluble organic matter 0·12%, moisture 0·77%, total 100·00%. According to analyses quoted by Hatch and Corstorphine the proportion of trona to sodium chloride in some of the underlying layers is even higher than in the top layer, and one of them, two feet in thickness, consists of practically pure trona.

The layer of mud, exposed beneath the uppermost trona bed, was found at one point by probing to have a thickness of 15 in. The mud is of very dark olive-green colour and emits an unpleasant smell of fœtid vegetable matter. It consists of impalpably fine clay-substance, strongly impregnated with salts, and enclosing angular particles of quartz, occasional grains of felspar, and isolated flakes of altered biotite. Minute crystals of zircon and rutile were also noted. The mud contains a good deal of humus, and, according to Dr. J. Moir, small quantities of potash that cannot be extracted by water. Disseminated through it are small glistening crystals of a transparent colourless mineral that contains lime and soda, and has been identified by Dr. A. W. Rogers as gaylussite ($CaCO_3$, Na_2CO_3, $5H_2O$). The water extract of the mud is pale brown, but contains little humus. The only important constituents are common salt and sodium carbonate. Lime, magnesia, alumina, and potash are under 0·1%, and other common metals and lithia entirely absent. Sodium sulphate is present in traces only, and nitrates and nitrogen compounds were tested for with negative results. An analysis of a representative sample of the mud showed 17% NaCl, 12·3% Na_2CO_3, and 2·13% CaO. On withdrawing a stick or any other object that has been forced down into the mud there is a fairly powerful evolution of inflammable gas. This, according to Dr. Moir, contains 64% of methane and 1·5% of hydrogen. Carbon dioxide is absent. The gas probably owes its origin to the decay of vegetable matter washed into the pan from the upper slopes of the crater.

In regard to the muds and clay underlying the trona beds very little is known. A specimen of mud from a depth of about 40 ft. in the bore-hole, already referred to, which Dr. Wagner saw in the laboratory of Messrs. Littlejohn & Whitby, while similar on the whole to the mud above described, is somewhat lighter in colour and evidently contains less organic matter. A partial analysis of this material gave the following result: Na_2CO_3, 10%; NaCl, 15·5%; K_2O, 0·16%. Specimens of the clays encountered at greater depths in the bore-hole are, unfortunately, not available for examination.

All the deeper excavations in the pan floor are, as already stated, filled with a reddish-brown brine, that may be looked upon as the mother liquor of the saline deposits. An analysis of a sample of this brine from near the centre of the pan gave NaCl 17·9%, Na_2CO_3 11·2%, while a sample taken from a depth of 24 ft. in the bore-hole was found to contain 18·3% NaCl and 8·31% Na_2CO_3. Sodium sulphate is only present to the extent of 0·01%, and K_2O, Li_2O, MgO, CaO, BaO, FeO, and Al_2O_3 were tested for with negative results. The brine is thus essentially a mixture of solutions of chloride and carbonate of sodium. Of special interest is the almost complete absence of sodium sulphate, which is present in considerable quantities in the waters of most closed basins.

The chief problems in connection with the salt pan relate to the origin of the remarkable crater-form depression and of its saline deposits. So far as present knowledge can be accepted as a guide, a crater-shaped depression, such as the salt pan, can only be formed in three ways, namely: (1) by the impact of a great meteorite, (2) by a volcanic explosion, (3) by the subsidence of a cylindrical segment of the earth's crust within a ring shaped fault. Dr. Wagner has also heard it suggested that the pan may represent a vast dissected pipe-shaped vesicle or amygdaloidal cavity in the granite, that was originally filled with soda-rich vapours. It is so difficult, however, to imagine the conditions under which a huge gas-bubble could form in a plutonic rock in process of slow crystallization that this ingenious hypothesis does not even seem worthy of serious consideration.

The much discussed Coon Butte crater, of Canyon Diablo, in Arizona, which in configuration somewhat resembles the salt pan, is now generally regarded as having been formed by the impact of an enormous iron meteorite, numerous fragments of which have been found in its neighbourhood. The walls of the crater are formed in this instance of sandstone and limestone, "crushed and shattered to an extraordinary degree," and dipping inward on all sides at angles of from 10° to 80°. The floor of the depression has been explored by means of bore-holes to a depth of 1,100 ft. It is occupied by surface soil and recent lake beds, below which there was struck a considerable thickness of white sand-like rock-flour, containing particles of nickeliferous magnetite and schreibersite, and lumps of pumiceous material clearly derived from the fusion of the local quartz sandstone. This zone of comminuted and fused material is in turn underlain by normal unaltered sandstone. The evidence in favour of the meteoric origin of the crater is thus overwhelming. In the case of the salt pan, on the other hand, such evidence is completely lacking. In the first place there is no trace in or near the pan of any material to which an extra-terrestrial origin can be assigned, and in the second place the granite forming the walls of the depression shows no signs of brecciation or fusion. The meteoric hypothesis may, therefore, with confidence be dismissed.

If the pan represents the orifice of a volcanic pipe, it is certainly remarkable that there should be no lava or tuffs near it. In this connection it must be remembered, however, that there are in South Africa and elsewhere examples of great volcanic necks, formed by gas explosions, that are occupied exclusively by non-volcanic fragmentary material. Geitsi Gubib, in South-West Africa, of which an excellent description has recently been published by A. W. Rogers, is perhaps the best illustration. It is a conspicuous ring-shaped mountain, marking the position of an enormous pipe, about two miles in diameter, filled entirely with a peculiar breccia of reddish-brown colour, which is composed of small angular chips of shale, sandstone, quartz, and felspar with occasional lumps of quartz gabbro, the only igneous rock present. Assuming that the throat of a volcano of this type were cleared by a final explosion, and that the ejected fragmentary material forming a cone about the orifice were completely removed by denudation—part of it being necessarily swept into the open crater—then, provided that the vent had been cleared to a sufficiently great depth, we would be left with a funnel-shaped depression similar to the salt pan. The presence of the encompassing ridge of granite could be ascribed on this hypothesis to the formation, prior to the actual drilling of the pipe of a dome-shaped elevation in the granite, comparable to that in the shales and sandstones surrounding the Saltpetre Kop pipe near Sutherland, in the Cape Province. At the same time the protection against the agencies of denudation afforded the granite, immediately surrounding the orifice of the vent, by the cone of fragmentary material—granite debris—that is assumed originally to have covered it, can hardly have failed to contribute to the formation of an annular ridge.

The subsidence of a cylindrical mass of granite, within a circular fault, would also account satisfactorily for the formation of a crater-shaped depression, and in this case the prominence of the rim above the surrounding country could be put down to the upwarping of the granite bordering the sunk area. Apart from the fact that faults of the type postulated are confined to volcanic regions there is thus, if the saline deposits occurring in the depression be left out of consideration, little to choose between the faulting and the volcanic hypotheses.

Turning to the question of the origin of the saline deposits, the important points to be borne in mind are: (1) that here is a completely enclosed basin from which no material, whether soluble or insoluble, that once gets in can escape unless carried out by wind in the form of fine dust; (2) that the pan crater must originally have stood open to a far greater depth than at present; (3) that, since the pan dries up completely in winter, the evaporation from its surface must exceed the combined inflow from surface and subterranean sources. The deposits that have in the course of time accumulated within the pan are clearly referable in their entirety to material: (*a*) brought up from below, on the supposition that the pan is of volcanic origin; (*b*) washed down from the crater walls; (*c*) derived from the atmosphere by rain falling within the catchment area of the pan, the principal substances thus introduced being carbon dioxide, chlorine, nitric acid, nitrates, and fine wind-borne dust; (*d*) brought into the pan in solution by the agency of underground waters and concentrated at its surface by evaporation and capillary attraction.

It is a well-known fact that sodium carbonate waters are specially characteristic of many regions of expiring volcanic activity, and sodium chloride is a common constituent of volcanic vapours and gases. One would be perfectly justified, therefore, if the pan were definitely proved to be of volcanic origin, in assuming that the saline deposits within it were formed primarily by the agency of alkaline magmatic solutions and vapours. There is, however, as we have seen, considerable uncertainty in regard to the precise manner of formation of the pan, and as we have, moreover, a number of well authenticated examples of trona deposits formed within closed basins as a result of the normal atmospheric weathering of igneous rocks, it appears desirable to inquire whether material, derived from the other sources enumerated, may not have been responsible or at any rate contributed largely to the formation of the deposits. In this connection some detailed knowledge in regard to the composition of the red granite surrounding the pan is essential. As developed on the inner side of the southern rim of the crater, it is a coarse-grained, red rock, composed almost entirely of brownish-red felspar and bluish-grey quartz, which are accompanied by isolated plates and foils of very dark biotite. According to Cohen, a deep green amphibole is also present, but this mineral must be sporadic in its distribution, since it was not noted in the material examined by the writer. The brownish-red felspar, which appears to the naked eye to be quite homogeneous, proves on investigation to consist of an intimate perthitic intergrowth of soda-orthoclase and albite-oligoclase, the former mineral being as a rule somewhat turbid owing to decomposition. In addition there are present small homogeneous grains of an acid soda-lime felspar, apparently indentical with that intergrown with the orthoclase. The evidence on this point was, however, not quite conclusive. The quartz occurs in large clear blebs, traversed by lines of liquid inclusions. The biotite, which is present in very small quantities only, encloses minute needles of rutile. Other accessory minerals noted in the rock are zircon and apatite, which occur in the form of microscopic crystals.

A partial analysis of a specimen of the granite gave the following result: CaO, 0·75%; Na_2O, 6·10%; K_2O, 1·25%. It is thus a typical soda-granite, which, to judge by the very small proportion of ferromagnesian minerals present, can contain but very little iron and magnesia.

The principal products of the decomposition of a rock of this character are quartz, kaolin, and sodium carbonate, and it is taken into consideration that a single ton of the granite would, on the assumption that all the sodium that it contains went to form trona, give rise to some 330 lb. of that mineral, and that, whatever may have been its origin, very large quantities of disintegrated granite must in the course of time have been washed into the pan, it is difficult to avoid the conclusion that a considerable amount of trona has actually been formed within the pan as a result of normal atmospheric weathering.

The sodium chloride occurring in the trona deposits, muds and brine, is generally assumed to have been brought up from below by volcanic vapours and gases.

Sight must not, however, in this connection be lost of the fact that rain water invariably contains a small percentage of dissolved chlorine, probably representing for the most part sodium chloride raised by vapour from the ocean. The amount is greatest near the sea, and diminishes rapidly as one proceeds inland, as is most clearly shown by the so-called "chlorine maps" that have been issued by several of the North American States.

The only available data in regard to the chlorine content of Transvaal rain are based on observations and tests made at Johannesburg during the three months ended February 28, 1911. In this period, during which 15·01 in. of rain fell, it is calculated that 1·863 lb. of chlorine was brought down, per acre, to the surface of the earth. At Bloemfontein the mean annual precipitation of chlorine per acre for the years 1911 and 1912 was 2·543 lb.

Taking the yearly precipitation at the salt pan at 2 lb. per acre, which is equivalent to 3·31 lb. of sodium chloride, then since the catchment area is 179 acres—the original catchment was in all likelihood considerably larger—the comparatively brief period, geologically speaking, of 100,000 years would have sufficed for the accumulation within the pan of 26,450 tons of NaCl from this source alone. It can scarcely be doubted, moreover, that considerable amounts of both Na_2CO_3 and NaCl have in the course of time been introduced into the pan by the agency of underground waters, since it is clear that the pan, especially at the time when it stood open to a far greater depth than is now the case, acting as a huge well must have received the sub-surface drainage from quite a considerable area of the surrounding granite country.

There is, however, an insuperable obstacle to the view that the whole or even a considerable part of the pan salts could have been formed as a result of the decomposition of the granite and granite debris, and by the evaporation of underground water draining into the pan, and that is the scarcity in the trona layers, muds and brine of potash; seeing that the granite contains 1·25% of K_2O, so that for every 100 lb. of trona there should be produced 12·4 lb. of K_2CO_3. The almost complete absence in the trona layers and brine of potassium compounds could only be explained on the supposition that these have been adsorbed by the muds intercalated with and underlying the trona deposits. Were this so, the ratio of K_2O to Na_2O in the muds should be higher than in the granite. As a matter of fact, however, the mud underlying the uppermost trona layer contains under 1% of K_2O, and that taken from a depth of 40 ft. in the bore-hole only 0·16%.

The scarcity of calcite and gaylussite in the pan deposits, having regard to the lime content of the granite and to the fact that conditions at the salt pan are eminently favourable to the concentration of calcium compounds at and near the surface, is equally inexplicable and furnishes additional proof that the weathering of the granite, etc., could only have furnished a comparatively small part of the pan salts. It must be concluded, therefore, that volcanic gases and vapours and magmatic solutions did contribute largely to the formation of the trona deposits, or in other words that the pan is of volcanic origin. While a deep bore-hole put down at its centre would appear to be the only means of finally solving the problem of the salt pan, the volcanic theory may thus be said to hold the field.

In regard to the age of the pan they had no definite evidence to go upon, but the fact that there are no vestiges within it of any rocks belonging to the Karroo System, which must at one time have covered the whole of this portion of the Bushveld, indicates that it is of post-Karroo age. If the conclusion reached above is correct it may have been formed during the period of volcanic activity that gave rise to the kimberlite and allied pipes and probably the great Geitsi Gubib vent.

THE STOREY'S CREEK TIN-WOLFRAM MINE.

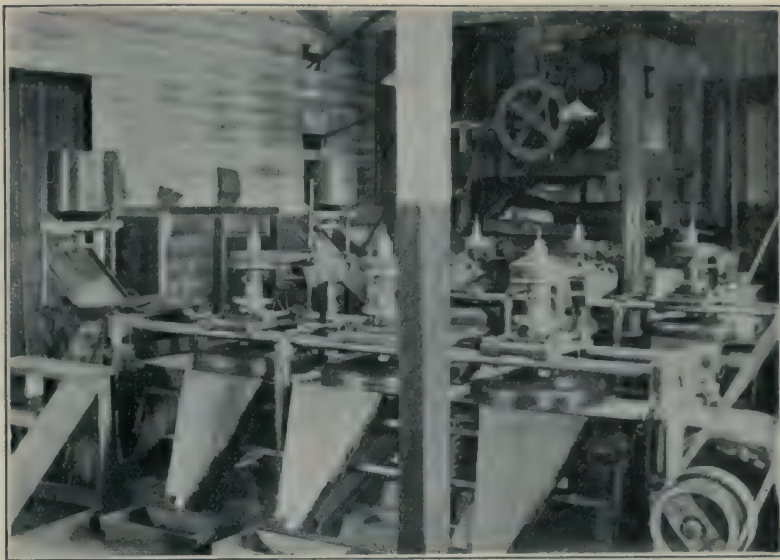
A paper by Joseph Miller describing the tin-wolfram mine at Storey's Creek, Tasmania, is published in the *Chemical Engineering and Mining Review for* December. This article is of special interest as it gives the results obtained by the Thompson-Davies magnetic separator, made by the Rapid Magnetting Machine Co., of Birmingham.

The lodes traverse quartzitic slates at an acute angle, and numerous vertical and horizontal faults tend to make mining difficult. The minerals are irregularly distributed in the lodes, with a tendency to accumulate near the walls. There is practically no fine mineral disseminated through the gangue. Pieces of solid wolfram from 3 in. to 6 in. cube are common, while bunches of radiating wolfram imbedded in quartz and weighing up to ½ cwt. have been discovered. In several instances some tons weight on tin-wolfram were extracted in as many feet. To attempt to arrive at the value of the lodes by ordinary sampling methods would be impossible. The quartz is highly fractured, and quite half of the ore going to the crushers passes through 1 in. grizzly. The minerals found so far are wolframite, cassiterite, pyrite, arsenopyrite, chalcopyrite, scheelite, and micaceous hematite, with tourmaline and pyrolusite pseudomorphs occurring rarely. As the mineral is massive, it is easily detached from the gangue, making the process of concentration a simple one. In order to avoid the crushing of massive mineral in the mill the initial concentration takes place in the mine, where the rich ore is hand-picked.

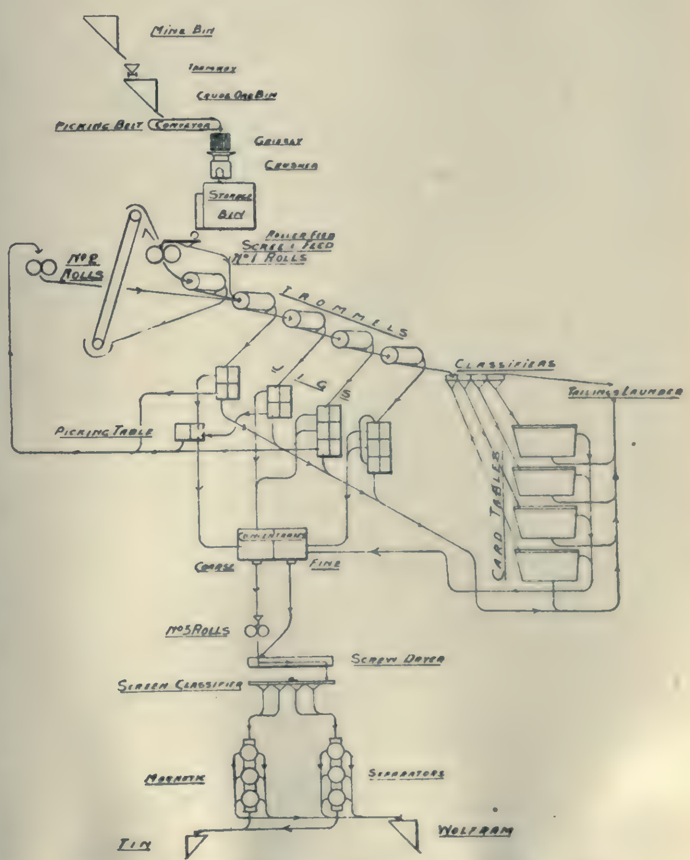
No. 1 lode has been driven on for a length of 500 ft., and stoping has proceeded for a length of 240 ft., the lode averaging fully 24 in. in width. No. 1 adit was extended to No. 2 lode (130 ft.) Drifts north and south (650 ft.) have proved No. 2 lode to have an average width of 48 in. with a maximum width of 80 in. in the north drift; the mineral contents are two-thirds wolfram and one-third cassiterite, against 50% of each in No. 1 lode. Stoping on No. 2 lode is now in progress over a distance of 400 ft. These lodes are 130 ft. apart at the adit levels, but converge and should intersect at depth. No. 3 lode, about the same distance west and underlying at a higher angle, should also be intersected by the others at a greater depth. The adit will be extended to cut this lode when labour is available. It is interesting to note that the north drift on No. 2 lode is now under the detritus resulting from the metamorphosed greenstone of Ben Lomond, and consequently the outcrop of the lode in this locality has not been exposed and worked out by early miners, as have been nine-tenths of the lode outcrop of the district.

The concentrating plant is situated down the creek below No. 1 adit, and about midway on the known length of lodes. No. 2 adit is being driven in the vicinity of the mill and will command the central portion of the mine. The ore is conveyed from the mine bin by tramline to the crude ore bin, thence by conveyor belt to the 1 in. grizzly. The ore passing through goes to the storage bin and the oversize to the breaker. A friction roller-feed delivers the ore to a shaking screen with ½ in. holes, the undersize from which is sent to No. 2 trommel, while the oversize is fed to 24 in. by 12 in. rolls. The ore from the rolls enters No. 1 trommel which has ½ in. holes, the undersize going to No. 2 trommel, while the oversize is returned by an elevator to the rolls. Nos. 2, 3, 4, and 5 trommels have screens with ⅜ in., ¼ in., ⅛ in., and 1/16 in. apertures respectively, the oversize of each going to the jigs, which are screened to suit. The undersize of No. 5 is conveyed to hydraulic classifiers, from the spigots of which each of the Card tables receives its share of fine ore for treatment. The product from No. 1 compartment and gate discharge of No. 1 jig goes to the picking table, while that from No. 2 compartment is sent to No. 2 rolls. The spigot discharge from No. 1 compartment of No. 2 jig and from Nos. 1 and 2 compartments of Nos. 3 and 4 jigs, after sieving to remove attrition mineral and sand, goes direct to the concentrate-draining bin, while that from No. 3 compartment of No. 3 jig is re-crushed in No. 2 rolls. The spigot discharge from No. 3 compartment of No. 4 jig is returned to the head of the same jig. The firsts from the three coarse Card tables are treated in a hydraulic cleaner, which eliminates the fine pyrite, and the overflow is re-treated on the Card slime-table. The seconds from the tables are re-treated, being fed by water jet, when poorer ore is being sent to the mill. The overflow from the classifiers is practically clear. The tonnage treated by the mill is from 30 to 35 tons in eight hours, and the recovery is from 85 to 90%. Subjecting the ore to finer comminution would mean a smaller mill capacity with greater loss in the tailing. The fine and coarse concentrates are kept separate in the draining bins, the former going straight to a screen drier, while the latter is passed to No. 3 rolls before reaching the drier. Classification, like drying, is absolutely necessary as a preliminary to magnetic separation. The screen classifier consists of a series of sieves, the coarsest having six holes per linear inch. The oversize is returned to the rolls in preference to setting the rolls closer. By this means less slime is created and a better separation is obtained. The present output of concentrate is 6 to 7 tons per fortnight.

The ore from the classifer bins is fed to the hoppers of two Thompson-Davies electro-magnetic separators, each having



The Thompson-Davies Electro-Magnetic Separator.



Flow-Sheet of Storey's Creek Concentrator.

3 poles and 3 discs and a 15 in. feed belt. Each machine is capable of giving six magnetic products and one non-magnetic product. The ore, in as many different grades as possible, is delivered to the feed belt by means of glass funnels, having orifices to suit the grade of concentrate. The material falls on to an inclined smooth convex plate, which serves to spread it in a thin even layer by the time it reaches the belt, where, to get the best results, the layer of ore should not be more than the depth of the particles being fed. The revolving separating discs are adjustable laterally and vertically, and adjustments as well as alteration of speed can be made without stopping the machine. This is a prominent feature of the apparatus, enabling the operator to note the results of an adjustment while the separator is working. The electric current is supplied to each machine by a small dynamo, the amperage being from 2 to 3 on each disc at 100 volts.

On Storey's Creek concentrate, which varies from 50% to 66% wolfram, each of the separators will treat comfortably 10 cwt. per 8 hours. The assay-value of the products is cassiterite 65% to 68% metallic tin, and wolfram 70% to 74% tungstic acid, WO_3. The latest actual result is 73·2% WO_3.

Iron Production in Manchuria.—The development of an iron and coal industry at Pen-chi-hu, 45 miles south-east of Mukden, in Manchuria, provides one of the interesting examples of the aid given by the Japanese in the development of Chinese mineral resources. The first blast-furnace was started at the beginning of 1915, and a second in December last. The *Far Eastern Review*, published at Shanghai, contains in its January issue an account of this enterprise.

It is scarcely a dozen years since the vast coal deposit that underlies Pen-chi-hu was tackled seriously. Then the town was known as "Pen-hsi-hu," and consisted of a collection of a few score hovels. Now it is a town of many thousand inhabitants, all of whom either labour in the mines and works connected with them or are supported by those who do. It is due to the foresight and determination of Baron K. H. Okura, one of the best known among Japan's captains of industry, that not only the mine has reached its present high stage of development, but that the iron furnaces have been built and the way paved for the creation of a great steel industry with its rolling mills and other finishing machinery. Baron Okura first secured the concession to mine at the then Pen-hsi-hu in 1906 on the property which was turned over to the Sino-Japanese company, of which he is the head, in 1910. Baron Okura soon pointed out to the Chinese the advisability of using the coal in some manufacture rather than shipping it out as raw material. This was a novel idea to them, and it was not until it was shown that the coal could be used to convert the iron ore of an adjoining mine into pig iron, a much more valuable commodity than the iron ore and coal of which it was made, that an agreement to organize the steel company was signed in October, 1911. Three years elapsed before the iron deposit was opened and the first blast-furnace was ready to receive its first charge of ore. The tapping of this furnace produced the first iron that had come from Manchurian materials since the days of Tung Chih of the Manchu dynasty, and the first iron that ever had been made there by modern metallurgical methods. The capacity of the company has now been doubled, and it is expected that the full capacity of 260 tons per day will soon be reached. The three factors essential for a modern steel industry are present. The coal is of coking variety, the iron ore is reasonably rich and low in sulphur and phosphorus, and the supply of limestone, as flux, is plentiful, pure, and cheap. The coal is a semi-anthracite, and the iron ore is a magnetite that runs to 70% iron. The limestone is found underlying the coal measures and conveniently outcrops so that it can be run to the furnace top in mechanical conveyors as it is needed.

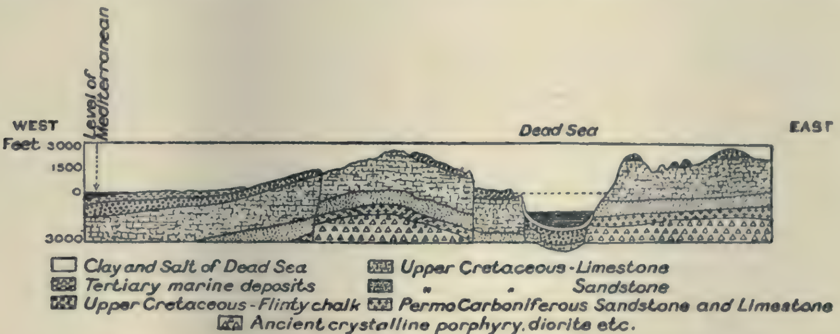
MAP OF MANCHURIA AND KOREA.

The iron ore for the Pen-chi-hu furnaces is of two sorts, one a rich magnetite containing 70% of iron but not inexhaustible in quantity. This is found at the Miao-er-kou mine and is being developed as rapidly as possible. In addition to this, there is a vast tonnage of low-grade ore running between 30 and 40% iron, available in the hills around Pen-chi-hu, and favourably situated so far as transportation to the blast-furnaces is concerned. Upwards of 120,000,000 tons of this grade of iron is said to be available. It is not suitable for mixing with the richer ore, but needs concentration before smelting. In 1915, the company received specifications from England as to methods of treating this ore, and decided upon magnetic separation followed by briquetting under the Grondal system. The wet crushed ore after passing under the magnets is further concentrated on tables such as are used in other metalliferous mining operations. The final product, which contains about 60%, is briquetted and sintered in a kiln, after which it goes to the furnaces. Efforts are being made to obviate the sintering process by mixing the ore with lime and briquetting. At the start, the Miao-er-kou ore was not used alone, but was mixed with ore from the Angaku mine just south of Chinnampo, Korea. The analysis of the pig iron now produced is: carbon 3%, silicon 3·4%, phosphorus 0·06%, sulphur 0·05%, and manganese 0·20%. Some of the analyses have run as low as 0·02% in sulphur, but the higher figure is deemed not to vitiate the use of the pig iron by steel makers generally. It is expected that the phosphorus also will be considerably reduced as furnace conditions are gradually brought under more complete control and the composition of the charge regulated with this end in view. The ore strata at Miao-er-kou lie parallel with the slope of the mountain and are easily worked. According to estimates, 80,000,000 tons are proved, with a probability that further amounts will be disclosed as development proceeds. This estimate includes both the rich ore and the ore needing concentration. The cost of mining and transporting the ore is very low. The mines are less than six miles away from the furnaces, which have been built at the coal mines and limestone outcrops.

The erecting of the steel furnaces has not yet been begun, but the plans are drawn. At present the output of the two Pen-chi-hu furnaces, which ranges between 220 and 260 tons a day, is being shipped to the Japanese Government steelworks and there used with Japanese pig iron and other materials of Japanese origin, for steel making. The Pen-chi-hu coalfield lies near the Mukden-Antung railway to the north-east of the town of Pen-chi-hu and extends over an area of 15 square miles. The measures are from 500 to 550 ft. thick, and contain 17 seams of coal of varying thickness. The bottom of the measures lies on sandstone. Of the 17 seams of coal those marked out for future exploitation are 7 ft., 4½ ft., 3½ ft., 5½ ft., 9 ft., 3 ft., 3½ ft., and 4 ft. thick respectively. Mining was commenced in January, 1906. The first seam was met at the depth of about 200 yards. This pit will work the three uppermost seams. The sinking of a new incline with the aim of mining the lower seams was commenced in November, 1907. The third pit was started in 1910 to exploit the continuations of the three upper seams west of No. 1 pit.

Geology of the Jordan Valley.—The *Geographical Journal* for April contains a paper by Dr. E. W. G. Masterman on the Jordan Valley and its Lakes, read before the Royal Geographical Society in January. Owing to our military operations in Palestine against the Turks, scientific interest in this district has revived. George Adam Smith has said of the Jordan Valley that there is "nothing on the earth like this deep colossal ditch. No other part of the earth uncovered by water sinks 300 ft. below the level of the ocean; but here is a rift more than 150 miles long and 2 to 15 miles broad that falls at its south end to 1,293 ft. below sea level, while the bottom of the Dead Sea is 1,300 ft. deeper still."

The existence of this valley is due to a block faulting during the gradual elevation of the country to form the mountain ranges of western and eastern Palestine, which took place in the later part of the Cretaceous or early part of the Tertiary period. The fault extends from northern Syria, through the Bukaa or Cœlesyria, which lies between the Lebanon and Antilebanon, along the Jordan Valley, and ends in the gulf of Akaba on the Red Sea, a total distance of at least 360 miles. Possibly it extends also through the Red Sea into the famous rift-valley in Central Africa. All along this fault the strata eastwards have risen many hundreds of feet higher than those in the west, so that east of the Jordan the Nubian and Lower Carboniferous sandstone appear which on the west are buried deep under the Cretaceous limestone. According to some writers the whole of the Jordan Valley was once an arm of the sea from Akaba, and was cut off from the connection with the ocean by the rising of the land toward the south. The more modern view, however, holds that the considerable height of the great diagonal ridge of limestone, which now lies between the Dead Sea and the Gulf of Akaba, namely, 820 ft. above sea-level, is against the valley ever having been connected with the ocean. Whatever may be the fact, it is certain that in the early Glacial period, at the time when the deep valleys now leading to the Jordan depression were being formed, the Jordan Valley was occupied by a vast inland sea 105 ft. above the Mediterranean, over 200 miles long and 30 miles wide. The existence of such a lake is proved by the traces of old beaches at levels many hundreds of feet above the level of the lakes of to-day, and also by the vast deposits of stratified marl and gravel which cover the whole valley to great depths from the Lake of Tiberias southward, while the semi-fossil shells found in the high beach deposits show that the water there was only moderately saline.



Section across Palestine showing Depression of the Dead Sea.

The waters of the Dead Sea are impregnated with salt to an extraordinary extent, but varying very much in places. At the northern end the percentage is 24 to 33, or five times as much as the open ocean, which has 3·6 to 4% solids; but in the southern bay the waters are actually saturated and salt crystallizes out on the bottom. The main ingredients are chlorides of magnesium and sodium, but there are considerable quantities of calcium and potassium chlorides and traces of bromides and iodides. The latter do not exist in sufficient percentage to admit of successful commercial exploitation. The extraordinary saltness of the Dead Sea has been ascribed to three causes: (1) That its waters were once connected with the ocean, and that this water—salt at the time—has been concentrated by evaporation. This is very doubtful. (2 That the salts are derived from the erosion of rock, and the concentration of the vast amount of water impregnated with soluble salts in this way by the enormous evaporation that has been going on for untold ages. And (3) that the atmospheric transportation of salt from the Mediterranean has been a very important contributing factor, if not the chief one.

The Rickard Gold-Mining District.—As announced recently in our columns, gold ore has been discovered in Rickard Township, Ontario, and an option on the Raty property has been taken by the Mining Corporation of Canada, for which D'Arcy Weatherbe is consulting engineer. A description of the deposit is given by Percy E. Hopkins, of the Canadian Geological Survey, in *Canadian Mining Journal* for February 15.

Rickard township is situated 100 miles north of Cobalt, 40 miles north-east of Porcupine, and 10 miles west of Abitibi lake. It can be reached by navigable water from the towns of Matheson or Iroquois Falls on the Temiskaming and Northern Ontario railway, or from Low Bush station on the Transcontinental railway. Gold was found in July, 1917, by a Finn named John Raty at a point 200 yards from a telephone line which runs from Iroquois Falls to Couchiching Falls on the Abitibi river. Shortly after the discovery, representatives of two mining companies sampled the vein, but obtained low values. Later, in sinking, the prospector found a rich gold showing at a depth of five feet, which resulted in the Mining Corporation of Canada securing a working option. At the time of writing, January, 1918, the shaft was over 50 ft. in depth and much spectacular ore has been found.

The country is undulating, and the superficial deposits consist of stratified clay through which occasional rocks rise as high as 100 ft. above the stream valleys. Much of the forests in this particular area was destroyed by the big fire in 1916. The rocks are Pre-Cambrian, consisting of Keewatin pillow-lava schist (meta-basalt), with subordinate areas of altered diabase and cherty iron formation, all of which have been intruded by narrow dykes of hornblende-granite porphyry and quartz-diabase, probably of Algoman and Keweenawan age respectively. Gold was first found near the centre of the claim in a 3in. quartz vein striking east and west in a rusty weathered carbonate schist. The main deposit, however, is on the north part of the claim and strikes east and west for at least 600 ft. The vein averages about 6 ft. in width and has a vertical dip. The quartz, the chief gangue mineral, has a milky appearance. Calcite occurs as a replacement mineral in the wall-rock rather than in the vein itself. Talc and sericite are frequently found, while felspar is not so prominent. Among the sulphides, pyrite is the most abundant, and there are small quantities of copper pyrite, galena, and molybdenite. Molybdic oxide and native copper are secondary minerals near the surface. The gold, which is extremely coarse in places and varies in colour from light to dark yellow, occurs in crushed portions of the quartz with tellurides and other minerals, the gold usually crystallizing out after the tellurides. In the samples examined two tellurides have been identified, namely, tetradymite (bismuth telluride) and altaite (lead telluride). A silver telluride may be present, as considerable silver was found on analysis. The magmatic waters connected with the prophyry intrusions may have had much to do with the ore deposition.

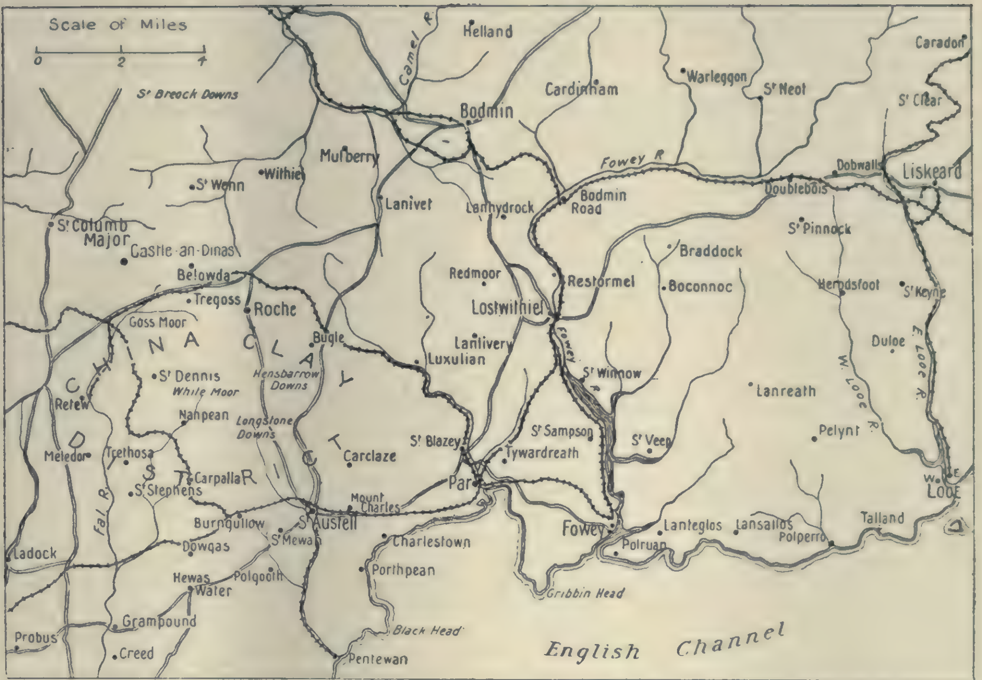
The Mining Corporation of Canada is meeting with encouraging results so far. A small steam plant is in operation and diamond-drilling will be done.

Aluminium Smelter for India. — The *Times of India* for February 13 contains an article outlining a scheme for the production of aluminium in India. As is already well known, there are in India enormous beds of laterite high in alumina partaking of the nature of bauxite. Important deposits are found near Jaigarh, on the west coast, in Ratnagiri district, about 120 miles south of Bombay, and also in the district of Belgaum farther to the south-east. Other deposits are in Central India, the Central Provinces, Bihar, Orissa, Chota Nagpur, Rewa, Bhopal, and Kalahandi. Shortly after the outbreak of war, the Indian Government approached Tata, Sons & Co., of Bombay, inviting this firm to undertake the production of aluminium from these ores. We gave an outline of the great steel industry founded by Tatas in our issue of March. After careful investigation it was decided to utilize the headwaters of the Koyna river as a source of power for the necessary hydro-electric plant. This river rises in the Western Ghats and flows southward for 40 miles along a deep valley, and, turning eastward at a point 40 miles east of Jaigarh, subsequently joins the Krishna river, which crosses the peninsula and empties into the Bay of Bengal. The rainfall in the Western Ghats is unusually high, as much as 250 inches falling during the monsoon. At one time it had been intended to build a storage reservoir here in connection with a plan for irrigating tracts of land in the Deccan that are subject to drought and famine, but for various reasons the scheme never came to fruition. Accorcing to the Tata plan, a dam is to be built at the foot of the valley so as to impound the waters into a lake having an area of 56·8 square miles, with a maximum depth of 300 ft., and a storage capacity of 132,100 million gallons. A pipe-line 6,000 ft. long will take the water to the power house 1,700 ft. below, where it will be possible to generate 300,000 to 350,000 electrical horse-power. The current will be carried to the coast, where there are plenty of sites for factories and works. No details are yet to hand as to the capacity of the aluminium smelter to be erected at Jaigarh, but in any case it will not monopolize the current. Facilities will also be given to firms who desire to produce nitrogen compounds from the air, to smelt chromium and tungsten ores, or to manufacture soda, phosphorus, ferro-manganese, etc. Altogether the scheme constitutes one of the biggest electro-chemical and electro-metallurgical ventures ever contemplated.

Castle-an-Dinas Wolfram Mine.—In our last issue we recorded that the South Crofty Company has purchased the Castle-an-Dinas wolfram property. A short report by Josiah Paull, the manager, has since been issued. We quote from this herewith.

The property known as Castle-an-Dinas wolfram mine is situated on the Goss Moor, and is about 3 miles distant from St. Columb Road and Roche stations on the Par-Newquay railway. The position is marked on the map on the opposite page. It is held on a lease of 21 years from September 29, 1916, granted by the Duchy of Cornwall. The first development carried out when working was started in February, 1917, consists of an adit level, which has been driven for a distance of approximately 975 ft. and is now, at its deepest point, about 120 ft. from the surface. It is connected to the surface by two air shafts, which will later be used as winzes for stoping purposes. A second adit level has been started from a point further down the hill, and been driven a distance of 750 ft., reaching a point 25 to 30 ft. beyond the mouth of the first adit level. This level is 66 ft. under the first adit, and is connected to it by a winze sunk from the mouth of the latter. This lower adit is on a level with the top of the grizzlies above the mill ore-bin, so the ore from the whole of the underground workings can be trammed direct to the mill.

The ground developed above the level of the top adit level may be said to average quite 30 lb. of wolfram per ton over a width of 3 ft., so that above this level at least 11,000 tons of ore of the value mentioned has been proved. In the lower adit the lode was very



MAP OF ST. AUSTELL DISTRICT, CORNWALL, SHOWING POSITION OF CASTLE-AN-DINAS.

poor over rather more than half the distance driven and may be considered only barely payable for the next 200 ft.; but for the last 100 ft. driven it gave rather better assay-values than those for the level above. Mr. Paull is of opinion, from the strength and appearance of the lode in the bottom level, that there will be a continuation of the better ore over at least the next 950 ft. of driving.

A mill building has been erected, and the following plant installed: One new 56 h.p. Tangye gas engine with producer plant, a rock-breaker, two combined conveyor and picking belts, two sets of crushing rolls for bringing the ore down to the necessary concentrating size, two elevators for raising the ore from the rolls to two sets of trommels for sizing purposes, two Hartz jigs, one James concentrating table, and one Frue vanner, besides sundry mining appliances for handling the concentrate, &c. There is also a small office, miners' changing house, and blacksmiths' shop. Crushing operations were commenced at the end of January this year, and up to the present time 400 tons of ore has been crushed for a yield of approximately 10 tons of wolfram, 5 tons of which has already been sold, assaying 65% tungstic acid and 0·25% tin. This yield would give the impression of a much higher value than that stated, but this is explained by 5 or 6 tons of selected ore collected from time to time in development work having been crushed. The yield of the average run of ore from development has been well up to the figure stated, 30 lb.

Mr. Paull is of opinion that the property is by far the best purely wolfram mine in the county of Cornwall. In order to complete the plant so that work if necessary may go on during the full 24 hours, some additions are required in the form of electric lighting equipment and plant for the final treatment of the vanner concentrate and middling. The purchase price of the property is £20,000 in cash.

[In J. H. Collins' "Observations on the West of England Mining Region," there is the following note on Castle-an-Dinas: "Very ancient workings on an elvan, some tin was being raised in 1836. In 1852-73, 25 tons of black tin was sold. The tin occurs in small stringers traversing an elvan." No mention is made of wolfram, which was valueless in those days.—EDITOR.]

SHORT NOTICES

Iron Ore Mining.—In the *Iron and Coal Trades Review* for April 6, W. Barnes describes machines used in the mining of iron ore by open-cut in the Midland counties. The article supplements the information given by the author in our March issue.

Extinguishing Coal-Mine Fires.—*Engineering* for April 12 publishes a translation of an article by A. Plassard in the Journal de la Société de l'Industrie Minerale describing his system of extinguishing fires in coal mines or in coal storages by injecting slime or mud by compressed air through crevices or bore-holes into the affected areas.

Lena Goldfields.—In the *Mining and Scientific Press* for March 30, W. E. Thorne describes drilling operations undertaken for the Lena Goldfields, Siberia.

Flotation.—In the *Bulletin* of the Canadian Mining Institute for March, F. O. Groch and W. E. Simpson describe the Groch flotation machine.

Antimony.—The April *Bulletin* of the American Institute of Mining Engineers contains a paper by Chung Yu Wang on methods of antimony smelting practised in China.

Dwight-Lloyd Sintering. — *Metallurgical and Chemical Engineering* for March 15 contains a description of a large Dwight-Lloyd sintering machine erected for the Carnegie Steel Co., used for sintering flue dust, pyrite cinder, and magnetite concentrate.

Electric Furnaces.—*The Iron & Coal Trades Review* for April 12 contains an illustrated description of the Stobie electric steel furnace in use at the Dunston works of the Stobie Steel Co.

Losses of Mercury.—In the *Mining and Scientific Press* for April 6, W. J. Sharwood discusses losses of mercury in amalgamation practice, and reproduces many records of consumption of mercury in stamp-mills in various parts of the world.

Sodium Cyanide.—In the *Journal of Industrial and Engineering Chemistry* for April, W. J. Sharwood describes modern sodium cyanide and gives the method of analysis.

Decantation.—The *Monthly Journal* of the Chamber of Mines of West Australia for November contains a paper by V. T. Edquist on continuous decantation at the Yuanmi gold mine.

Leaching with Nitric Acid.—In *Metallurgical and Chemical Engineering* for March 15, G. C. Westby describes experiments with nitric acid for leaching copper ore.

Leaching at Anaconda.—In the *Mining and Scientific Press* for March 16, Frederick Laist and H. J. Maguire give some results of experience at the copper-leaching plant at Anaconda.

Sulphuric Acid Manufacture.— In the *Mining and Scientific Press* for March 30, Courtenay De Kalb describes the sulphuric acid plant of the Calumet & Arizona Copper Company. This plant has been erected to utilize the sulphurous gases at the smelter for the production of acid required for leaching the copper-carbonate ores at the Ajo mine.

Tinplate Manufacture.—At a meeting of the Liverpool section of the Society of Chemical Industry held on February 15, T. Lewis Bailey read a paper giving an outline of present methods of manufacture of tinplate, with a discussion of the methods for recovering metal and chemicals from the tin dross.

Analysis of Aluminium Alloys.—Paper read by B. Collitt and W. Regan before the Nottingham section of the Society of Chemical Industry, Febuary 20.

Tungsten in Alaska. — In *Economic Geology* for March A. M. Bateman describes a scheelite deposit near Fairbanks, Alaska.

Geology of Bendigo. — *Economic Geology* for March contains a paper by F. L. Stillwell giving the results of his geological examination of the Bendigo goldfield recently made for the Australian Advisory Council of Science and Industry.

Malayan Clays.—In the *Geological Magazine* for April, J. B. Scrivenor continues the discussion of the origin of clays and boulder-clays in the Federated Malay States.

Mining in Manitoba.—In the *Bulletin* of the Canadian Mining Institute for March, E. L. Bruce gives an account of the developments of ore deposits in Northern Manitoba, at Flin-flon and Schist Lake.

Dargalong Silver-Lead.—In the *Queensland Government Mining Journal* for December, Lionel C. Ball describes the Dargalong silver-lead district near Chillagoe.

Zinc in Tonkin.—The *Engineering and Mining Journal* for February 16 publishes a translation of a paper by A. Lochard in the Bulletin of the Société de l'Industrie Minerale on the production of zinc ores in Tonkin, French Indo-China. The ore is going largely to Japan now that shipments to France are difficult. We published some information on this zinc region in our issue of October last.

Russian Petroleum.—At the meeting of the Institution of Petroleum Technologists held on March 19, D. Ghambashidze read a paper on the Russian petroleum industry and its prospects. The author reviewed the recent progress in the various oilfields of the Caucasus and the Caspian sea. The paper was written before Russia went down before Germany.

Lubricating Oils.—At the April meeting of the Institution of Petroleum Technologists, A. E. Dunstan and F. B. Thole read a paper on the relation between viscosity and the chemical constitution of lubricating oils.

Military Explosives.—A course of three lectures on modern military explosives has been delivered by James Young before the Royal Society of Arts.

Fuel Briquettes.—In the *Colliery Guardian* for April 5, F. J. Warden-Stevens describes the method of making fuel blocks as practiced in South Wales. The blocks are, in the trade, known as "patent fuel." Hitherto the blocks have been mostly exported to the Continent and South America for use on locomotives, but recently the English railway companies have been adopting them.

Ore Selling.—*Metallurgical and Chemical Engineering* for April 1, and the *Engineering and Mining Journal* for March 23, print the Colorado State Committee's report on the schedules of prices paid by smelters for ores and concentrates.

World's Output of Gold.—The *Statist* for April 13 contains an article on the output of gold throughout the world. The figures for the output of the British Empire are estimated at £56,139,030; those for the United States £17,344,100, Mexico £2,500,000, Russia £4,000,000, other countries not itemized £8,000,000; total for the world £87,983,103.

RECENT PATENTS PUBLISHED.

3,422, 3,423 & 3,426 of 1917 (113,835, 113,856, 113,839). M. J. INSULL, Chicago. Methods of reducing tungsten ores and consolidating the metallic powder to coherent form.

3,722 of 1917 (114,025). A. SINDING-LARSEN, Christiania. Method of making solid iron from iron sponge by treating the latter with carbonic oxide and passing the resulting gaseous iron carbonyl through an electric furnace where the iron is deposited in coherent form on an iron core.

3,815 of 1917 (104,885). NORSKE AKTIESELSKAB FOR ELECTROKEMISK INDUSTRI, Christiania. Method of treating precipitated titanium hydrate for the production of white pigment.

4,321 of 1917 (114,204). W. J. JOBBINS, Aurora, Illinois. Recovering aluminium from dross and skimmings by reducing with a hydrocarbon and then reacting with nitrogen or air to form aluminium nitride, then treating the nitride with water to form alumina and ammonia.

4,954 of 1917 (105,558). NORSK ELEKTRESK METALINDUSTRI, Sarpsborg. Converting zinc powder into liquid zinc in a rotating electric furnace, the rotating action serving to remove the external oxide coating of the zinc particles.

6,551 of 1917 (106,489). P. COMMENT, Dijon, France. Production of anhydrous sulphide of zinc suitable as a white pigment, by calcining a mixture of zinc sulphate and zinc persulphide in presence of sulphate of soda.

12,265 of 1917 (114,105). J. A. MORTERUD, Duluth, U.S.A. Method of tempering and hardening copper.

17,045 of 1917 (114,282). WESTINGHOUSE LAMP CO., New York. Method of producing tungsten and molybdenum wires from the powdered metal.

18,737 of 1917 (114,288). G. W. S. SIMPSON, London. Pneumatic separator intended for grading powders, especially nitrate caliche.

NEW BOOKS

The Principles of Economic Geology. By William Harvey Emmons. New York: Mc Graw-Hill Book Co.; London: Hill Publishing Co. Price 17s. net.

Dr. Emmons' qualifications to write a treatise on the principles of economic geology are sufficiently well known. This book is beyond doubt a philosophical and masterly exposition of current American thought in regard to the problems presented by mineral deposits. The author describes the book as "an attempt to present as briefly as practicable a perspective of the science of metalliferous and non-metalliferous deposits to advanced students of geology." Following a short introduction and discussion on the classification of ore deposits, the opening series of chapters are devoted to a general treatment of the different types in accordance with the scheme given in the preliminary chapter on classification. Each of these chapters is prefaced by a conveniently summarized statement of the structural features of the class, under the headings occurrence, composition, shape, size, and texture. Then follow a series of chapters on primary ore-shoots, deformation, faulting and folding, dynamic metamorphism, superficial alteration and enrichment of ore deposits, openings in rocks, structural features of openings and of epigenetic deposits, metasomatic processes, mineral association in veins and wall-rock alterations, metallogenic provinces and epochs, and the composition and sources of ascending thermal metalliferous waters. These chapters, together with those previously mentioned, make up about half the volume. The second half is divided into chapters in accordance with the nature of the metal, and the last two chapters are devoted to miscellaneous metalliferous deposits and deposits of the non-metals. The title of the last chapter is not a particularly happy choice for the subject matter, since it deals with such materials as building stones, slate, clay, fuller's earth, natural abrasives, glass sand, etc., with which we are accustomed to associate rather different ideas than these of sources of non-metals. The foregoing briefly summarizes the contents of the work, and affords some idea of the general scheme of treatment. One of the most interesting and illuminating chapters is that on superficial alteration and enrichment, a subject to which our American friends have devoted much study, and to whose labours we owe so much of our knowledge. The author thinks that some readers will disagree with certain features of his classification of deposits and with the weights he has set down for certain processes in the formation of various ores. I am one such reader. Nevertheless the concise and novel character of the particular diagrams to which the author refers fully justifies their publication, even if there is room for debate on some of their details. The science of ore deposits is young, and Dr. Emmons' book is admittedly designed to teach the study of mineral deposits rather than preach finalities, so that the inclusion of some debatable material is inevitable and in no way detracts from the general value of the work. The examples described are mainly American. While this method of treatment is perhaps best suited to transatlantic conditions, it somewhat narrows the view of the principles of economic geology, for, in the wider sense, one of the great fundamental principles of the science is the application of the comparative method to the study of ore deposits. It does not seem possible to reap the full benefits to be derived from the comparative study of ore deposits without drawing somewhat extensively on examples situated outside the American continent. Copious references are given to original papers. The book teems with useful information and is well put together, and the author is to be congratulated on producing a work eminently suited not only to teaching economic geology to advanced students but to the practical requirements of the experienced engineer.

W. H. G.

Mathematics for Engineers. Part I. By W. N. Rose. Cloth, octavo, 520 pages. Price 8s. 6d. net. London: Chapman & Hall.

Until comparatively recently the teaching of pure mathematics was in the hands of Cambridge men, who kept their pupils severely within the bounds of abstract science and, in their applications, specialized on astronomy and the undulatory theory of light. The study of statics, dynamics, and applied mechanics was directed by other teachers, who might have a position in the mathematical world or not, but their courses, presumed a previous knowledge or concurrent study of the Cambridge course. The weak point of the whole arrangement was that the "examples" in the mathematical course were not applicable to the engineer student's requirements, and in many cases were indeed absurd and utterly futile. Moreover the direct study of many of the problems was unnecessarily elaborated. Of more recent years, however, efforts have been made to combine, in a way, the study of mathematics and mechanics, by employing mechanical "examples" in the practice of each mathematical theorem. So the budding engineer does not have to worry himself with the fly walking along a curved wire, or about the complicated but prodigiously clever Euclidean method of inscribing a regular pentagon in a circle. It is also allowed to take many mathematical truths for granted instead of spending hours or weeks in grasping the intricacies of the proofs. Some Cambridge men are inclined to resent this short cut to knowledge, though they perhaps forget that the beginner was always allowed to assume the ratio of the circumference to the diameter of a circle without waiting until he understands the method of calculating it by Taylor's Theorem. The same may be said of the permitted use of logarithms.

The above disquisition serves to explain the method adopted by Mr. Rose in preparing the present book, which is based on his lectures on engineering mathematics at the Goldsmiths' College of the University of London. The part now issued includes elementary and higher algebra up to the exponential theorem, plane trigonometry, mensuration, and the study of graphs. Practically all the examples are culled from engineering problems. The second volume will deal with the calculus, spherical trigonometry, and harmonic and vector analysis. We have read the first volume with great interest, and we look forward to Vol. II. with pleasurable anticipation.

E.W.

Mining Manual and Mining Year Book, 1918. By Walter R. Skinner. Cloth, octavo, 950 pages. Price 17s. 6d. net. London: W. R. Skinner, and *The Financial Times*.

This is the thirty-second annual volume of Skinner's Mining Manual. As our readers are fully aware, this work gives particulars of all mining companies registered or known in London; the information given relating to the directorate, management, capitalization, the nature of the business, the results obtained, and a brief résumé of the history of each company. We have on many previous occasions commented on the excellent method of presenting the information, and on the remarkable degree of accuracy of detail.

Gypsum, Celestine, and Strontianite. By R. L. Sherlock and B. Smith. Octavo, paper covers, 64 pages. Price 2s. net. London: The Geological Survey.

A second edition of the 3rd volume of the special reports on the mineral resources of Great Britain has been issued by the Geological Survey. In this pamphlet the properties, uses, treatment, and modes of occurrence of gypsum, anhydrite, celestine, and strontianite are described, and details of the workings in all parts of Great Britain are given, with statistics as to output. In the new edition some additional matter respecting deposits of gypsum in Nottinghamshire and Somerset, and estimates of the reserves of gypsum existing in the various districts described, have been added.

Geology of the Barberton Gold Mining District. By A. L. Hall. This is Memoir 9 of the Geological Survey of the Union of South Africa. Price 7s. 6d.

Miners' Phthisis, Its Causation, Incidence, and Prevention. By H. R. Sellars, late development shift-boss at Geldenhuis Deep. This is sold at 1s. by the author at 1, St. Frusquin Street, Malvern, Johannesburg.

Russian and English Commercial Correspondence. By S. G. Stafford and W. Chevob-Maurice. Price 2s. net. London: E. Marlborough & Co.

Blast-Furnace Breakouts, Explosions, and Slips, and Methods of Prevention. By F. H. Willcox. This is Bulletin 130 published by the United States Bureau of Mines. It is the third of a series of reports on hazards and the prevention of accidents at blast-furnace plants.

"The Ironmonger" Metal Market Year-Book. The twelfth issue of this convenient reference book gives information up to the end of 1917. It contains a very large amount of useful statistical and trade information relating to the production of metals and their manufactured forms.

COMPANY REPORTS

Dolcoath Mine.—The report of this mine, at Camborne, Cornwall, for the half-year ended December 31, shows that 34,540 tons of ore was raised and treated, for a yield of 467½ tons of tin concentrate. The yield was 32·3 lb. per ton. The receipts from the sale of the concentrate were £67,806. Arsenic sales were £2,191, and other items brought the total receipts to £71,804. The expenses were £61,118, and the lord's royalties £4,630, leaving a profit of £6,055, out of which £2,526 has been written off for depreciation of buildings and plant. As compared with the previous half-year, the ore treated was 634 tons less, the yield 32½ tons less, the receipts £7,476 more, the working costs £5,290 more, the royalty £427 higher, and the profit £1,698 more. R. Arthur Thomas gives an account of the underground work, and in reproducing his remarks, we may remind readers that we published a longitudinal section of the workings in our issue of March a year ago.

After having succeeded in driving the 490 fm. level for 152 fathoms west of Wheal Harriet shaft, and to within a few fathoms of the cross-course, work had to be abandoned on account of the excessive heat. At the time of suspension, the lode was becoming disordered, indicating the nearness of the cross-course. The proving of this lode at a greater depth than where it was worked at Stray Park (388 fm. level) is important, and, at present, a diamond drill is employed in putting down a bore-hole from below a cross-cut south of the Stray Park shaft at the 375 fm. level to obtain a core of the lode at about the equivalent depth of a 430 fm. level, and 30 fm. east of Stray Park shaft. Stray Park section was a consistent producer previous to reaching the 375 fm. level. Obtaining samples of the lode at the depth indicated will be a valuable guide as to the subsequent development of the comparatively large area of unexplored ground in this part of the mine. In New Sump section no ore is being drawn from below the 290 fm. level. The 375 fm. level is being driven east of the subsidiary shaft with the object of opening up for working some low-grade ore standing in the old workings. Some explorations are still being carried on at the 338 fm. level east of New Sump shaft on a north part of the Main lode series; the results obtained are encouraging, although, so far, only small quantities of payable tin ground have been discovered. The 210 fm. west level on the South Entral lode has been driven 32 fm.; the lode for this distance has not been found to be payable, but recently a small and rich branch has been discovered. The upper levels in the Old Sump section, notably the 130 and 150 fm. levels, have been recently explored for arsenical pyrite, and a considerable amount of clearing has been done in preparation for stoping the portion of the lode remaining, which will produce low-grade tin ore and arsenical pyrite. The upper levels also around New Sump shaft are contributing this class of ore, and further clearance and restoration of the old levels and workings will enable still larger quantities to be mined. In the Eastern section no development work has been possible owing to shortage of miners; this is a pity because the section, particularly in the upper levels, offers inducement for exploration. A diamond-drill hole was put out (and completed at the end of September) for a total distance of 530 ft. in a southerly direction from the 510 fm. level, 10 fm. east of the cross-course, west of the Eastern shaft, to locate the Dolcoath Main lode which has been faulted by this cross-course. This lode was found at a distance of 493 ft., and 30 ft. of it was passed through; assuming a normal dip, the actual width of the lode would be 19 ft. Valuable information has been obtained from an examination of the cores, a small section of which indicated the presence of rich tin values in a favourable lode mixture. Prospecting holes were subsequently drilled on the 470 fm. level north of the Main lode between New Sump and the Eastern shaft, the 425 fm. level north of Wheal Harriet, and north of the 375 fm. level at Stray Park shaft, in all for a total distance of 1,108 ft. Many branches and a great deal of altered granite were passed through in these drilling operations but, on the whole, the results were disappointing, although in some instances, encouragement has been given for subsequent development work.

Basset Mines.—This company was formed in 1896 under limited liability to acquire the Basset and South Frances tin mines south of Redruth, Cornwall, that had previously been worked on the cost-book plan. Francis Oats, chairman of De Beers, is chairman of the company. Small dividends on the preference shares were paid in 1911 and 1912. The pumping costs are necessarily high, and the water often causes trouble. The report for 1917 shows that owing to shortness of labour the amount of ore raised was less than the output for the previous year, the figures being 26,486 tons as compared with 32,419 tons. The yield of tin concentrate was 457 tons as compared with 601 tons, and the yield per ton was 38·6 lb. as compared with 41·5 lb. The receipts were £59,569, and the cost £61,000, leaving a loss of £1,522. This loss following on losses during previous years brought the debit balance to £23,422. As regards development, the 340 fm. level west of Pascoe's shaft and the 330 fm. level east of Pascoe's shaft are disclosing ore averaging 40 lb. per ton.

Nundydroog.—This company belongs to the John Taylor & Sons group operating in the Kolar gold-mining district, Mysore State, South India. Milling started in 1882, and dividends have been paid regularly since 1888. The report for the year 1917 shows that 99,345 tons of ore was raised and treated, yielding 79,382 oz. of bullion by amalgamation; 144,116 tons of tailing and slime was cyanided and gave 9,807 oz. bullion; the total gold was equivalent to 79,586 oz. fine, and realized £337,348. During the previous year 98,000 tons of ore and 173,154 tons of tailing and slime yielded gold worth £340,786. The working cost was £177,052, royalty £21,912, amounts written off £40,502, and dividends £94,333 at the rate of 33⅓%. The introduction of finer grinding has improved the extraction by both amalgamation and cyanide, and at present the recovery is 98%. As regards development, the most important ore-body, which extended for 1,166 ft. on the 3,500 ft. level from a point 435 ft. south from Oriental shaft to 445 ft. south from Kennedy's shaft, has not opened up so well on the 3,650 ft. level, where it is only 570 ft. long. This ore-body has been developed on the 3,800 ft. level in Kennedy's section for 240 ft. A winze below this level has proved ore 28 inches wide assaying 2 oz. 8 dwt. per ton. The explorations on the 3,650 ft. level north from Oriental shaft have not been so successful. The total ore reserve on December 31 was estimated at 202,800 tons, as compared with 217,300 tons the year before.

Ooregum Gold.—This company belongs to the John Taylor & Sons group operating gold mines in the Kolar district, Mysore State, South India. Mining commenced in 1888, and dividends have been paid continuously since 1891. The report for 1917 shows that 155,080 tons of ore was raised and sent to the stamps, where 76,763 oz. of fine gold was extracted, and that 205,497 tons of tailing and slime was cyanided for a yield of 13,924 oz. The total output of gold was 90,687 oz. which realized £384,716. The working cost was £199,252, the royalty £6,439, allowance for depreciation £25,000, and allocation to reserve £6,000. The dividends totalled £120,231, being at the rate of 30% on the 481,544 ordinary shares of 10s. each and 40% on the 240,000 preference shares of 10s, each. Owing to the shortening of the ore-shoot in Bullen's section by disturbed ground and cross-courses, less development was possible than usual, but the reserve shows only a small decline at 414,783 tons, as against 420,841 tons the year before. In Oakley's section the developments on the 54th, 55th, and 56th levels were not generally favourable, but on the 57th level the lode for 166 ft. averages 2¾ ft. wide and 21 dwt. per ton, so that there is a prospect of a new supply of ore.

Balaghat Gold.—This company operates the most northerly of the series of gold mines in the Kolar district, Mysore State, South India, belonging to the John Taylor & Sons group. Its early fortunes were unfavourable; then came a profitable period from 1900 to 1907; but since then the mine has only just paid its way on a much reduced output. The report for 1917 shows that 28,525 tons of ore was milled for a yield of 18,061 oz. of gold bullion, and 51,600 tons of sand and slime yielded 3,861 oz. The total yield of bullion was 21,922 oz., equal to 19,929 oz. fine, worth £84,437. The yield was about £9,000 higher than the year before, owing partly to the ore being of higher grade and partly to the better recovery in the sand plant. The working cost was £75,903, royalty £4,106, allowance for depreciation £3,466, additions to plant, etc., £6,088. The debit balance at the end of the year was £22,840. The ore reserve was fully maintained, and stood on December 31 at 30,076 tons, together with 10,725 tons of accumulated sand and slime. In addition 30,000 tons of sand is to be re-treated. Development on the Balaghat lode during the year has continued to disclose ore. For instance, on the 3,675 ft. level, the deepest in the mine, the last 104 ft. driven averaged 2 oz. 16 dwt. per ton over 2 ft. 8 in.

Tharsis Sulphur & Copper.—This company has its headquarters in Glasgow, and operates pyrite mines in the south of Spain, with metal works in Great Britain. The report for 1917 shows that 402,097 tons of ore was raised from the Calanas mine. The output of copper was 4,066 tons. The Sierra Bullones and North lodes at the Tharsis mine have been developed recently, and at the former the ore is ready for extraction. The profit for the year was £158,077, out of which £156,250 has been paid as dividend, being at the rate of 12½%.

Mason & Barry.—This company operates the San Domingos sulphur and copper mine at Mertola, Portugal, and was formed in 1858. The report for 1917 shows that exports of ore have been restricted by shortage and control of shipping facilities. The ore raised was 154,762 tons, and the shipments 43,529 tons, the latter figure comparing with 202,176 tons in 1916. The profit was £18,498, out of which £18,517 was distributed as dividend, being at the rate of 10%, as compared with £83,327 and 45% in 1916.

Esperanza Copper & Sulphur.—This company was formed in 1906, to acquire the Esperanza, Forzosa, and Angostura pyrite mines in the south of Spain. G. Mure Ritchie is chairman, and T. D. Lawther is managing director. The report for 1917 shows that 35,785 tons was raised from the Angostura, and 50,848 tons from the Esperanza and Forzosa, a decrease of 10,480 tons and 11,612 tons respectively as compared with the figures for 1916. The shipments from the port of Huelva were 79,278 tons, being 17,078 tons less than the previous year, and fully 60,000 tons less than customers' requirements. The copper contents of the ore exhibit no marked change, but the amount of cupreous ore shipped has considerably decreased. The reserve at Angostura is 233,000 tons and at the Esperanza and Forzosa 639,000 tons. Developments continue to be satisfactory. The production of copper precipitate by washing was 104 tons. The profit for the year was £20,367, which is carried forward owing to the large amount of capital required under present conditions.

Barramia Mining & Exploration. — This company was formed in 1909 by John Taylor & Sons, as a subsidiary of the Egypt & Sudan Mining Syndicate, to acquire the Barrahme gold mine, which is situated between the Red Sea and Edfu on the Nile. The lodes are characterized by rich pockets, which have yielded the profits. No more of these pockets are now being discovered. The report for 1917 shows that 7,700 tons of ore was raised and treated, for a yield of gold realizing £9,971. The working cost was £31,091. The allowance for depreciation and taxes was £846. The year began with a debit balance of £1,971, and ended with a debit balance of £6,105. The results of mining and development have been so discouraging that it was decided to suspend underground work at the end of the 1917 for the time being. The cyanide plant for treating sand and slime was started on March 10 of this year. The reserve of this material is 30,000 tons. During its treatment, the future policy with regard to the mine will be considered.

Sudan Gold Field. — This company was formed in 1904 by John Taylor & Sons to prospect in the Sudan between the 20th and 22nd parallels of latitude. Eventually operations were centred on the Om Nabardi property. Additional capital was raised in 1908, and dividends have been paid for the years 1914, 1915, and 1916. The report for 1917 shows that 33,300 tons of ore was treated for a yield of 14,270 oz. of gold bullion, and 22,000 tons of tailing for a yield of 1,328 oz. The value of the bullion was £55,046. The working cost was £44,638, £6.000 was allocated to capital expenditure, and £3,440 was written off for depreciation. The net profit was £11,194, which was carried forward. The profit was less than the year before, partly because the grade of the ore was 2 dwt. lower, and partly owing to the scarcity of labour and cost of supplies. For the latter reason also the amount of development work was restricted, and the reserve is estimated at 45,281 tons as compared with 60,193 tons at the end of 1916. In the northern section the lode is promising. A plant to treat current and accumulated slime with a capacity of 1,500 tons per month will be completed shortly.

Ivanhoe Gold Corporation.—This company was floated in 1897 by the late Whitaker Wright to acquire a gold mine at Kalgoorlie from a Melbourne company of similar name, which had done well for its shareholders during the two preceding years. After the Whitaker Wright collapse, F. A. Govett became chairman and Bewick, Moreing & Co. were appointed consulting engineers. For many years handsome dividends were paid continuously, but on the failure to find much ore below the 2,420 ft. level the rate of distribution fell slightly four years ago. The report for 1917 shows that 233,719 tons of ore was raised. By amalgamation gold worth £117,998 was recovered; 21,730 tons of concentrate was roasted and cyanided for a yield of £81,318; 109,546 tons of sand tailing gave £55,450; and 102,533 tons of slime gave £133,490; the total yield of gold was £388,256, and the yield per ton 33s. 2d. The percentage of recovery was 87%. The total cost was £266,812, or 22s. 10d. per ton. An allowance of £13,627 was made for depreciation of investments. The shareholders received £105,000, being at the rate of 10½%. The ore reserve has been re-estimated and now stands at 1,035,874 tons averaging 34s. 2d. per ton, as compared with 1,002,096 tons averaging 36s. 3d. per ton a year ago. Development in the upper levels has contiuued to disclose ore, but of lower grade. Diamond drilling in depth has not disclosed anything of value.

Chinese Engineering & Mining. — This company was formed in 1900 to acquire coal mines at Kaiping, Chi-li, North China, and was reconstructed in 1912 in order to effect a working arrangement with the Lanchow company, a Chinese-owned coal-mining company operating in the same district. The businesses of the two companies are now controlled by the Kailan Mining Administration. The report for the year ended June 30, 1917, shows that the Kailan sold 2,766,873 tons of coal, a slight increase over the previous year, and that the profit was $3,791,986, of which the Chinese Engineering & Mining Company's share was $2,146,973. The company's net profit was £291,562, out of which £125,000 has been distributed as dividend, being at the rate of 12½%. A large balance is kept in hand, to provide for excess profits duty.

Gurum River (Nigeria) Tin Mines.—This company was formed in 1911 to acquire alluvial tin ground on the Gurum river, five miles north-west of Naraguta, Nigeria. Financial assistance was, in 1916, given by the Niger Company, whose engineers, Laws, Rumbold & Co., undertook the direction of operations. Additional properties have been acquired and are being developed. The report for the eighteen months ended September 30 last shows that 142 tons of tin concentrate was won, realizing £14,562, and that the net profit was £6,783. The loan has been partly paid off, and the remaining liability of £7,000 has been extinguished by the issue at par of shares to that amount.

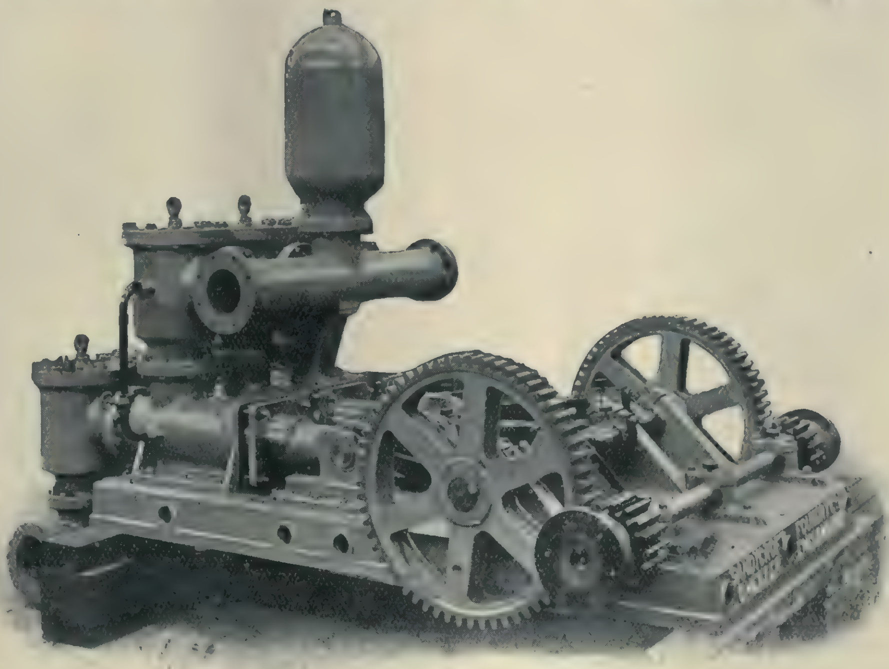
Plymouth Consolidated Gold Mines.—This company was formed by Bewick, Moreing & Co. in 1914 to acquire a gold mine in Amador county, California, which had been reopened on the recommendation of W. J. Loring, one of the partners. The report for 1917 shows that 127,750 tons of ore was treated, yielding £99,166 by amalgamation and £41,571 in concentrate, a total of £140,737, or 22s. per ton. The recovery was 86%. The cost at the mine was £90,573, or 14s. 2d. per ton. After the payment of American taxes and allowing for depreciation, the net profit was £34,983, out of which £24,000 has been distributed as dividend, being at the rate of 10%. The mine continues to develop well. On the 2,150 ft. and 2,300 ft. levels the north foot-wall shoot is wide and of a grade higher than the average of the mine.

Mexican Mines of El Oro.—This company used to belong to the Exploration Company group, but the control passed to France in 1910. The report for the year ended June 30, 1917, shows that, from the resumption of operations in September, 1916, to the end of the financial year, 74,948 tons of ore averaging $22·61 gold and 13·4 oz. silver per ton was raised, which, together with 9,135 tons averaging $8·72 gold and 5·1 oz. silver, was sent to the mill. Out of this ore, 165 tons of high-grade ore was hand-picked for shipment to smelters. The yield of bullion was worth $1,980,765. The accounts show receipts of £440,818, and a net profit of £271,174, out of which £115,500 has been distributed as dividend, being at the rate of 55%. The sum of £100,000 has been set aside for the purposes of testing and buying other properties, and this business will be conducted by a separate company to be formed later. Development has disclosed no new ore at depth, and the extent of the ore in the upper levels is fully determined. The reserve at June 30 last was estimated at 457,100 tons averaging $11·89 gold and 8 oz. silver, as compared with 505,300 tons averaging $10·4 gold and 6·4 oz. silver the year before.

Aramayo Francke Mines. — This company was formed in 1906 to acquire tin-wolfram-bismuth mines in southern Bolivia owned by F. Avelino Aramayo and his friends. The report for the year ended May 31, 1917, shows that the production of tin concentrate was 2,059 tons, of wolfram concentrate 226 tons, and of silver 523,283 oz., the figures for bismuth not being given. The sales were 2,027 tons, 193 tons, and 293,812 oz. respectively, and the income therefrom £154,968, £27,753, and £35,102. The mining profit for the year was £225,315, out of which £179,127 has been distributed as dividend, being at the rate of 30%. The silver is sold as ore, and the income from this source is increasingly important. No new tin ore has been found in depth at Chorolque. The bismuth output at Tasna is well maintained and the developments are satisfactory. The Chocaya mine is developing well, and both silver and tin contents are high.

Murex.—This company was formed in 1913 as a reconstruction of the Murex Magnetic Co., and it owns the Lockwood-Samuel patents for a wet process of magnetic separation. An account of the process was given in our issue of October, 1909. The company operates a custom separator near London where tin-wolfram and other concentrates and ores are treated. More recently it has commenced the production of tungsten powder and ferro-tungsten. The report for 1917 shows an income of £31,024 from royalties and treatment operations, and a net profit of £15,868, out of which £8,496 has been distributed as dividend, at the rate of 20%.

Three-Throw Pumps



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THE MYSORE GOLD MINING CO., LTD.

Directors: Captain W. Bell McTaggart (*Chairman*), Lord Ribblesdale (*Vice-Chairman*), Lord Glenconner, Hon. Mark F. Napier, Sir J. D. Rees, John Taylor, Robert Taylor. *Managers:* John Taylor & Sons. *Secretary:* W. F. Garland. *Office:* 6, Queen Street Place, London, E.C.4. *Formed* 1880. *Capital:* £305,000 in shares of 10s. each.

Business: Operates a gold mine in the Kolar district, Mysore State, South India.

The thirty-eighth ordinary general meeting of the Mysore Gold Mining Company, Ltd., was held on April 25 at the Cannon Street Hotel, London, E.C., Capt. W. Bell McTaggart (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts for 1917, said that 307,126 tons of quartz were milled, from which were recovered by amalgamation 160,627 oz. of bar gold, an average of 10·4 dwt. of gold per ton; 261,299 tons of tailings were treated for a yield of 26,705 oz. of bar gold, an average of 2 dwt. per ton; and 262,156 tons of slimes produced 29,985 oz. of bar gold, an average of 2·3 dwt. per ton. These quantities together represented a total production of 217,317 oz. of bar gold (equivalent to 198,446 oz. fine) of a realized value of £842,056. That amount was subjected to deductions for royalty, etc., of £49,346, and the expenditure on revenue account was £399,435, and the resultant profit £404,296. The following dividends had been paid: Interim dividend of 3s. per share, paid on July 19, 1917, £91,500; interim dividend of 3s. per share, paid on November 23, 1917, £91,500; final dividend of 2s. 6d. per share declared on April 14. The expenditure on capital account was £100,137. The quartz milled was 1,281 tons in excess of that crushed in the previous year, and slimes treated showed an increase of 89,830 tons. The gold extraction was more by 798 oz. and £5,313 in value, but the profit was less by £46,237. The reduced profit was mainly due to the heavily increased costs of mining requisites of all descriptions, arising from war conditions. The reserves throughout the mine aggregated 1,019,000 tons at December 31, 1916, and at December 31, 1917, they stood at 939,000 tons, a reduction of 80,000 tons. The effect of the enforced retrenchment in its application to explosives, coupled with a shortage of skilled labour and a diminished supply of unskilled labour, had been to materially reduce the scale of development work, as compared with pre-war times, and the opening up of fresh ore ground had of late fallen short of the ore extraction. In the circumstances the reduction of the reserves of ore in the past year by 80,000 tons only might be considered not unsatisfactory. There being no immediate prospect of any amelioration of the existing conditions, it had been deemed expedient for the time being and until circumstances again warranted the resumption of an increased output to reduce the monthly production of gold. Edgar's vertical shaft had now been sunk to the objective point, 117 ft. below the 51st level, or 3,807 ft. from surface. The equipment of the shaft below the 39th level, to which horizon it had been in use for some time, had to be of a temporary and incomplete character, by reason of the impossibility, at present, of obtaining the necessary sections of steel work for its permanent requirements. McTaggart's vertical shaft had also reached the required depth for the time being, namely, 3,003 ft. from surface, or 107 ft. below the 44th level. Edgar's shaft having reached the 51st level, it had been decided that the shaft could not, with advantage, be further continued. Below that horizon three levels were already being driven, and the provision of permanent shaft communication with these constantly increasing depths had now to be made. This would be in the form of a subsidiary vertical circular shaft, situated 815 ft. from Edgar's, to be known as "Edgar's secondary shaft."

The Right Hon. Lord Ribblesdale (Vice-Chairman) seconded the motion.

Mr. Edgar Taylor then gave particulars of progress at the mine. He said that discoveries in Ribblesdale's section again failed to produce much quartz for the mill, but discoveries made in stoping and by continuing to work outside the reserve areas and in the old parts of Crocker's and Ribblesdale's sections, made up to a considerable extent for deficiencies elsewhere. In McTaggart's section of the mine development operations had been carried on at the 33rd, 34th, 35th, and 37th levels from the auxiliary shaft, and at the 39th level from McTaggart's vertical shaft; the 44th level had also been recently started from the vertical shaft. The lode at this end of the property had alwavs been variable in value. At the 39th level south of McTaggart's vertical shaft the reef for a length of 227 ft. was 1 ft. 4 in. wide, assaying about 9 dwt. At the 37th level, advancing northwards above this, the reef showed a width of 3 ft. worth 13 dwt. In the upper levels of McTaggart's section work had been continued at the 790 ft. and 890 ft. levels north in the vicinity of (but below) Taylor's shaft. Some high values were obtained there, but the quartz was narrow. At the 11th south level near Rowse's shaft an inclined rise was put up 115 ft. on reef 2 ft. 2 in. wide, assaying 2 oz. and this had a valuable bearing on the discovery made at the 790 and 890 ft. levels under Taylor's shaft just referred to. There were two more or less parallel reefs in this section of the mine. In Rowse's section the 44th, 39th and 37th levels south had been driven aggregate lengths of 446 ft. No discovery of importance had yet resulted. At Ribblesdale's auxiliary shaft the 51st level south was started, and the 49th level south had also been continued a short distance. The 48th level south was advanced 307 ft. on reef 1½ ft. wide assaying 12 dwt. The most recent information was that the reef here was 2½ ft. wide, assaying 1 oz. 2 dwt. on March 15. This improvement in both width and value taking place, as it had, in a pioneer drivage, and little explored section of the mine, and following on the fair grade ore already opened up by the level gave great encouragement for further improvement, as lower levels were driven out. The 51st level south was now being pushed on to prove this ground in greater depth. Further north at Ribblesdale's main winze the 55th and 54th levels were started and driven short distances during the year. The reef was of good size, about 3ft. in width, and although at the moment they were in low-grade ore, they might soon expect improvement from indications at the 53rd level above. At the 51st level north of the main winze an extremely interesting development had taken place, as for a distance of 406 ft. southward from the auxiliary north winze reef had been opened up of a width of 3½ ft., assaying 14 dwt.

The resolution was then put to the meeting and unanimously adopted.

THE NUNDYDROOG COMPANY, LTD.

Directors: Captain W. Bell McTaggart (*Chairman*), P. C. C. Francis, Vere H. Smith, John Taylor, Robert Taylor. *Managers:* John Taylor & Sons. *Secretary:* W. L. Bayley. *Office:* 6, Queen Street Place, London, E.C.4. *Formed* 1880. *Capital:* £283,000 in shares of 10s. each.

Business: Operates a gold mine in the Kolar district, Mysore State, South India.

The twenty-fifth ordinary general meeting of the Nundydroog Company, Ltd., was held on April 24 at the Cannon Street Hotel, London, E.C., Capt. W. Bell McTaggart (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts for 1917, said that during the year 99,345 tons of quartz was crushed at the mill, against 98,000 tons in 1916, an increase of 1,345 tons. At the tailing plant 75,762 tons was treated, as compared with 87,766 tons in the previous year, a decrease of 12,014 tons, and at the slime plant 68,354 tons was dealt with in the year under review, whereas 85,388 tons was treated in 1916, a decrease of 17,034 tons. The total production from the three processes was 89,189 oz. of bar gold, as against 90,948 oz. in 1916, a decrease of 1,759 oz. bar gold. The total value of the gold won during 1917 was £337,348, whereas in the preceding year the amount realized was £340,786, showing a decrease of £3,438. A pleasing feature in connection with the year's record was the improvement in the extraction of gold from the ore. The figures showed that in 1916 the total extraction was 93·35%, whereas in the year under review it was 96·1%. The superintendent anticipated that the percentage would be still higher in 1918, as the benefit derived from the finer grinding of the ore only became evident during the latter part of 1917. In December last the extraction was as high as 98%, the sand and slime going to the waste heap containing only 7·2 grains per ton. The costs on revenue amounted to £177,052, and the receipts, after allowing for royalty, to £318,611, leaving a profit of £141,558, which was £13,011 less than that of the preceding year. The principal reason for this diminution in the profit was that the costs were £9,815 greater than in 1916, through the greatly increased cost of materials and stores, the higher freights and insurances in connection with the shipment of goods to India, and the substantial rise in the rates of exchange for remittances to the mines to meet local demands. Then there was the falling off in the gold returns of £3,438. In the profit and loss account, the total credits amounted to £150,067 and the debits £113,965. At the end of the financial year the credit balance was £36,101, out of which a balance dividend of 1s. 2d. per share was paid on March 21 last, absorbing £33,016, and leaving £3,085 to be carried forward to the credit of the current year. The total distribution of dividend was 3s. 4d. (less income tax) per 10s. share, being 2d. per share less than was paid in 1916. The capital outlay on new buildings, machinery, plant and furniture for the year was £24,598, and on the new circular shaft £12,903, together amounting to £37,501, which had been paid for out of the profits of the year in the usual way. The reserves of ore, as estimated by the superintendent at December 31 last, were 202,800 tons, as compared with 217,300 tons at the end of the previous year, being a decrease of 14,500 tons. This to some extent was accounted for by the fact that the total development footage for the year of 8,437 ft. was 1,467 ft. less than that of 1916.

Mr. John Taylor seconded the motion.

Mr. Edgar Taylor then gave particulars of the work at the mine during the year. He said that there were various causes operating from time to time during the year which interfered with progress. Work at some points was retarded by the prevalence of "rock-bursts." An accident to the electrical hoist at the 1,240 ft. level in Richards' incline shaft resulted in considerable disorganization of work for a time. There was also a shortage of compressed air for the rock-drills during the time that the pumps were run under this power, when the electrical pumping plant was being repaired. In regard to the shortage of compressed air, the large turbo-compressor, the installation of which was to render available very ample supplies of compressed air, had, owing to prevailing conditions, although ordered in 1915, been impossible to obtain, and had had to be done without. Partly owing to the decreased footage attained, and also the fact that the results of the exploratory work had not been quite as satisfactory in as 1916, the ore reserves showed a decrease of 14,500 tons, and now stood at 202,800 tons. Shaft-sinking during the year amounted to 985 ft. This comprised 523 ft. at New Circular shaft, which now totalled 1,438 ft. Work upon this shaft continued steadily and satisfactorily. The principal developments for some time past had been at Kennedy's and Oriental shafts. The new 3,800 ft. levels were driven from these two shafts, and the 3,650 and 3,500 ft. levels were continued north and south. Work to a less extent was also carried on at the 3,350 and 3,200 ft. levels north and south. The ore-body had been followed down to the 3,800 ft. level in Kennedy's section, where in the level north it had been opened up over a length of 240 ft., averaging 2½ ft. in width, assaying 19½ dwt. The 3,800 ft. level south had been extended some 354 ft. south of the shaft, and in the course of this drivage they had encountered quartz of somewhat better value and of a somewhat greater width than in the levels above, so much so that it became a most interesting point of exploration from the point of view of the possibility of again opening up payable ore in this direction either by the prolongation of this level or as greater depth was attained. At the 3,650 ft. level communication had been effected between Kennedy's and Oriental shafts. In Kennedy's section at this level the ore-shoot had been opened up over a length of 570 ft. For 201 ft. driven northward during the year the reef averaged 1½ ft. in width, worth 1 oz. 6 dwt. per ton. A cross-cut west was also driven and found another portion of the lode 3 ft. wide, assaying 1½ oz. Pending the further development of this western part it had, however, to be recognized that the developments at the 3,650 ft. level had been somewhat disappointing compared with the fine discoveries made at the 3,500 ft. level above, mentioned at last general meeting. Indications were not wanting that better results might attend the extension of the 3,650 ft. drive north of Oriental shaft, which had now passed through the big dyke. A strong quartz reef was visible at this point, and for a length of 33 ft. the value was 1 oz. 8 dwt. over a width of about 2 ft.

The resolution was carried unanimously.

OOREGUM GOLD MINING CO. OF INDIA, LTD.

Directors: Malcolm Low (*Chairman*), Sir J. D. Rees, Lt.-Col. Sir Donald Robertson, John Taylor, Edgar Taylor, Robert Taylor. *Managers:* John Taylor & Sons. *Secretary:* F. H. Williams. *Office:* 6, Queen St. Place, London, E.C.4. *Formed* 1880. *Capital:* £240,772 in ordinary shares and £120,000 in preferred shares, both of 10s. each

Business: Operates a gold mine in the Kolar District, Mysore State, South India.

The ordinary general meeting of the Ooregum Gold Mining Company of India, Ltd., was held on April 23 at the Cannon Street Hotel, London, E.C., Mr. Malcolm Low (Chairman of the company) presiding.

The Chairman, in proposing the adoption of the report and accounts for 1917, said the tonnage dealt with at the mill and at the cyanide works, amounting to 155,080 tons and 205,497 tons, showed a decrease of 237 tons and 17,858 tons, as compared with the figures of the year before, but shareholders had no cause for dissatisfaction in the result of the ultimate aim, namely, the production of gold. That production amounted to 90,687 oz., showing the slight increase of 66 oz. over the figure of the previous year, which recorded a result better than the company had ever before achieved. The decreases in quantities, in fact, were rather more than balanced by a slightly higher average yield of gold at the mills and a slightly better extraction from the slime. Two points in the report were specially noteworthy. The first was the satisfactory condition of the ore reserves, which at the close of the year stood at nearly 415,000 tons; and the second was the encouraging prospects which they were now having in the deepest levels in Bullen's and Oakley's sections of the mine. As regards the accounts, the income and expenditure account showed a realization of £384,716 by sales of gold. Deducting from that figure £21,621 for royalty belonging to the Mysore Government, and adding to the remainder sums aggregating £7,339 received as income from investments, rents, transfer fees, &c., the entire income of the year was £369,534. The various items of expenditure aggregated £199,252, leaving a profit of £170,282. In respect to buildings, machinery, and plant, circular shaft, and exploration, there had been written off £28,273, and £5,000 and £1,000 had been transferred to the reserve fund and the insurance and contingency fund. They had already paid £66,115 as dividends during the present year; and out of the balance of £63,975 they proposed to make a further distribution of 1s. 6d. per share on both classes of shares, bringing the total dividends of the year up to 4s. per share, or 40%, on the preferred shares, and 3s. per share, or 30%, on the ordinary shares, being the same as last year.

Mr. John Taylor seconded the motion.

Mr. Edgar Taylor then gave details of the year's work at the mine. He said they had been passing through a period of unproductive exploration in parts of Bullen's section of the mine, but they had also had favourable features, notably in the deepest workings at Oakley's section. The year's development work of 9,244 ft. compared with 11,159 ft. during the previous year. The shaft-sinking amounted to 626 ft. at Taylor's, Oakley's, and Bullen's shafts, and was practically the same as in the year before. Although no further sinking of the circular shaft had been accomplished during the year under review, principally with a view to economy in explosives, it had now become possible to resume operations here, and sinking had been recommenced. The ore reserves were estimated to amount to 414,783 tons, the small decrease of some 6,000 tons being due to the exclusion of certain blocks of ore-ground standing in Bullen's section, where the proximity of disturbing cross-courses rendered the calculation of tonnages uncertain. The ore milled was of slightly higher grade. The reduction plants showed increasing efficiency, and by a continuance of careful and systematic experiments it was hoped that even better extraction than at present would be possible. In Taylor's section the shaft had been sunk 204 ft. to the 58th level, and sinking was being continued. The drivage at the 56th level was now within about 200 ft. of the south boundary, and the 58th level had lately been started. Exploratory work in this section was looked to with much interest, although no discovery of value had recently been made. In Oakley's section the shaft had been sunk 240 ft., and was now 64 ft. below the 58th level. It was an interesting fact that the workings here were just about one mile in vertical depth below the surface The 57th level was started during the year and was driven 542 ft. In this level not only had fair values been obtained from the narrower portions of the reef, but for a distance of 166 ft. the reef had averaged 2¾ ft. in width, assaying 1 oz. 1 dwt. per ton, which was a great improvement on the level immediately above and a development that presented most encouraging prospects for the future as exploration proceeded in this section. The 56th, 55th, and 54th levels from Oakley's shaft were all connected up with Bullen's workings during the year under review. Summarizing the results at these three, the reef at the 56th level, over a length of 1,456 ft., averaged 1⅔ ft. in width, assaying 5 dwt.; and at the 55th level there was a width of 2½ ft., assaying 4 dwt. In both of these levels the ore was of less value than in the 54th level, where the reef averaged 18 dwt. over a width of 2 ft. The recovery in grade at the 57th level was, therefore, a matter not only of interest but of great importance. The 58th level, which was now being driven south from a winze, was in ore 1 ft. 6 in. wide, assaying 1 oz. 3 dwt. In Bullen's section the incline shaft was sunk 182 ft. to 87 ft. below the 57th level. The reef was intersected in this shaft at 1,696 ft., or 32 ft. below the 56th level, and for 27 ft. before it again passed into the foot-wall it averaged 2 ft. in width, assaying 16 dwt. per ton, The 57th level south had recently been commenced, and the latest information gave the value as ½ oz. over a width of 1 ft. 6 in. In the main shoot to the north of Bullen's shaft, down to the 55th level, they possessed large and highly valuable reserves of milling ore. The cross-courses were no new feature, and they could point to three previous occasions when rich ore had been found below them. The recurrence of a cross-course at the 56th level north involved a good deal of unproductive work before the ore-shoot could be recovered, and this would continue to restrict during the coming year some of the sources of milling ore, and with this in view a slight reduction in the monthly gold returns must be expected, consequent on a somewhat lower grade of ore being milled.

The resolution was carried unanimously.

BALAGHAT GOLD MINING CO., LTD.

Directors: Lord Ribblesdale (*Chairman*), Lord Glenconner, Lt.-Col. Sir Donald Robertson, John Taylor, Robert Taylor. *Managers:* John Taylor & Sons. *Secretary:* W. L. Bayley. *Office:* 6, Queen Street Place, London, E.C.4. *Formed* 1886. *Capital:* £212,600 in ordinary shares, and £95,400 in preference shares, both of £1 each.

Business: Operates a gold mine in Kolar district, Mysore State, South India.

The ordinary general meeting of the Balaghat Gold Mining Company, Ltd., was held on May 3 at 6, Queen Street Place, London, E.C., the Right Hon. Lord Ribblesdale (the Chairman) presiding.

The Chairman, in moving the adoption of the report and accounts, said 28,525 tons of quartz was treated at the mill, which quantity was slightly in excess of that of the previous year. There were 51,600 tons of slimes and sands submitted to the cyanide process, as compared with 57,438 tons in 1916. The total production was 19,929 oz. of fine gold of a value of £84,437, against a production in 1916 of 17,725 oz. worth £75,176. The improvement was due to higher grade ore having been treated at the mill and to the better extraction in the sands plant. The average yield was 14 dwt. 4 gr. per ton, against 12 dwt. 13 gr. per ton in 1916. The profit on revenue account was £5,062, against just under £3,000 for the preceding twelve months. The total credit to profit and loss account was £5,493, against which depreciation of machinery and plant amounted to £3,466. The debit balance carried forward was £22,940.

Mr. John Taylor seconded the resolution.

Mr. Henry C. Taylor then gave particulars of mining operations. He said that, despite the difficulties under which they were working, the scale of underground development had been more than maintained, and the ore reserves again showed a small increase. Both the main lode and the Balaghat lode had been further developed. Work on the main lode below the 1,450 ft. level had not yet resulted in any discovery of value, but in the 1,550 ft. level, according to the latest advice from the mine, the lode was of improved appearance and a width of from 2½ ft. to 4 ft. of quartz was being carried. On the Balaghat lode at much greater depths the year's work had been rewarded with a considerable measure of success. At the 3,675 ft. level, which was the deepest exploratory point in the mine, for an aggregate length of 275 ft. the quartz averaged 1 ft. 5 in. in width of a value of 2¼ oz. per ton. The latest advice gave the value as 1⅝ oz. for a width of about 1 ft. This was a substantial and satisfactory development even so far as it had already gone. It was apparently a fresh shoot of ore of importance, and quartz of value was extending southward under levels that had for the most part proved poor. It might mean that the level had now reached the line of better ore ground seen in the Nundydroog mine to the south of the property at higher levels.

The report and accounts were unanimously adopted.

DOLCOATH MINE, LIMITED.

Directors: Frank Harvey (*Chairman*), Oliver Wethered (*Vice-Chairman*), J. M. Holman, H. C. Godfray, F. A. Robinson, F. W. Thomas. *Manager and Acting Secretary:* R. Arthur Thomas. *Office:* Camborne. *Formed* 1895. *Capital:* £350,000.

Business: Operates the Dolcoath tin mine at Camborne, Cornwall.

The twenty-third annual general meeting of Dolcoath Mine, Ltd., was held at Salisbury House, London, E.C., on April 25, Mr. Frank Harvey (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts for the half-year ended December 31, said that the operations had been adversely affected by various causes, such as wages, which had gone up considerably without a corresponding result in work done, and the prices of materials, all of which had largely increased; but mainly owing to the higher price of £19. 5s. 3d. per ton for tin ores sold the receipts had been £4,900 more than for the previous six months. The receipts from the sale of arsenic should be noted. It was hoped the production of arsenic would continue to increase. The result, on the whole, was a profit of £6,055, against £4,356 at the last meeting. Development work had been almost impossible owing to the great shortage of miners, so many having joined the forces. Prospecting by diamond-drilling at various points had been carried out, but, so far, without very cheering results. They were very much in want of a good discovery. Considering the large area of the property and the many points yet to be tested they were sanguine that good deposits of ore would in due course be found. The board in conjunction with East Pool & Agar, Ltd., had agreed to buy the whole of the mineral rights of the Tehidy estate for the sum of £90,000. Dolcoath would take over the mineral rights in the lease it now held and also the adjoining properties of Cook's Kitchen and West Stray Park mines, while East Pool & Agar, Ltd., would take over the mineral rights in the lease they now held from the Tehidy estate with the adjoining properties of Carn Brea, Barncoose, and Wheal Tehidy. Dolcoath and East Pool & Agar companies would then hold between them all the remainder of the Tehidy mineral rights in the proportion of two-thirds and one-third respectively. In order to provide this company's share of the purchase money, £60,000, being two-thirds of the £90,000, and to provide some additional working capital the company created £75,000 debenture stock. £70,000 of this stock was offered *pro rata* to the shareholders, but, being over-subscribed, the whole £75,000 was allotted.

Mr. Oliver Wethered (Deputy-Chairman) seconded the motion.

Mr. R. Arthur Thomas, the manager, proceeded to give details of development which had been greatly restricted by lack of miners. They were diamond-drilling toward the north series of lodes, which were probably extensions of the South Crofty series, and would contain complex ores with wolfram, copper, and arsenic as well as tin. If the lodes proved valuable for wolfram contents they would be able to get more miners from the Government authorities.

The motion was carried unanimously.

THARSIS SULPHUR & COPPER CO., LTD.

Directors: Lord Glenconner (*Chairman*), W. P. Rutherford, Jr. (*Managing Director*), A. J. J. Messean, F. A. Ducoing, Hugh Brown, Sir Herbert E. Maxwell, S. C. Hogarth, L. O. Schmidt, R. Millet. *Secretary:* George Reid. *Office:* 136, West George Street, Glasgow. *Formed* 1866. *Capital:* £1,250,000.

Business: Operates pyrite mines in the south of Spain, with metal works in Great Britain.

The ordinary general meeting of shareholders of the Tharsis Sulphur and Copper Company, Limited, was held in Glasgow on April 24, the Right Hon. Lord Glenconner presiding.

Mr. G. Reid, the secretary, having read the notice calling the meeting and having submitted the auditors' report,

The Chairman said: I presume that, as usual, we take the report and accounts as read. Our mining operations in Spain were carried out last year without intermittance, notwithstanding increased difficulties in all directions. At Tharsis we continued the development of the Sierra Bullones and North Lode open-cuts, and at the former we now have ore uncovered and available for mining. Calanas mine has produced all the ore which we exported during the year. This mine continues to develop in a highly satisfactory manner. Due to our modern power plant at this place, which utilizes the exhaust steam available, it has been possible to effect very considerable economies, especially in view of the present enormous price of coal in Spain. Last year I informed you that we were erecting an electrical power plant and an ore-crushing plant at Corrales and a large central power station at Tharsis. The installations at the former place are now completed and the power station at Tharsis will be completed, we hope, in a few months' time. These important installations, which were part of our programme before the war, have naturally very greatly exceeded their estimated cost, but we considered it advisable to complete their erection and so be prepared for working on a large and economical scale when markets return to normal channels. I may add that, equipped as we are now with an ample power station at each of our three centres, we are in a good position to electrify our railway system should we consider this advisable at some future date.

Our practice of selling foodstuffs and clothing to our workmen and their families at cost price, which I described last year, became unworkable at the end of the year owing to the continually increasing cost. To meet this situation we started, on January 1 of this year, a system of selling all articles, both of food and clothing, commonly used by our workpeople and their dependants, at fixed prices, which on the average are approximately those ruling in 1914. Our communities being housed in our own property, a proper control is possible. This system has the advantage of ensuring to our mining population wholesome food at the old prices and eliminates profiteering by retailers. When the time arrives that we can release this food control we shall consider the adjustment of wages in accordance with the circumstances then ruling. This system, although entailing considerable labour to carry out effectively, removes entirely from our people in Spain the great question of the increased cost of living, with all its vexations troubles. Mr. Rutherford has recently returned from one of his periodical visits to the mines and left this system working with perfect smoothness among a contented community.

Turning to the work in this country, you will have seen from the report that the amount of ore treated at our four works exceeds anything done before. We have been able to do this through additional plant having come into operation. We hope in the future to increase the quantity still further when plant now under construction gradually comes into use. The products of our ores, all of which are essential materials, have realized satisfactory prices, except where we were working under old contracts. Against this we have been labouring under a constantly decreasing exchange with Spain and the greatly increased cost of coal, stores, and labour, which have had an adverse effect on the year's profits. We feel, however, that under all the circumstances the result is not unsatisfactory, especially when it is remembered that our dividend is paid free of tax.

With regard to the outlook for this year, I know you will not expect me to say much to-day, because, while we have the certainty of still higher costs, it is impossible to forecast the course of controlled markets. With regard to the future, I have already said that it has been our policy to develop our mines and equip them with the most modern plant, in order to be ready for any increased demand, to meet which we are now in a very strong position. Your cordial thanks are due to our staff in Spain and at home for their zeal during the past year. I am sure you will welcome the presence among us to-day of Monsieur Ducoing, who has come from Paris to attend our meeting. Our French directors take a very close interest in the company, and we value their collaboration very highly. With these remarks, I beg to move, "That the statement of accounts and balance sheet and the reports of the directors and auditors thereon for the year ended December 31, 1917, be and the same are hereby approved and adopted; that a dividend of 5s. per share equal to 12½% on the capital of the company, free of income tax, be now sanctioned and declared, payable on and after Friday, May 10 next; and that the balance of £27,739. 11s. 7d. be carried forward to the credit of the year 1918." I now conclude by calling upon Mr. Hugh Brown, a director of this company.

Mr. Hugh Brown: I beg to second the adoption of the report and accounts.

The Chairman: Does any shareholder wish to put any question or desire any information? No one. Then I declare the motion carried unanimously.

Mr. S. C. Hogarth: I beg to propose that M. Albert Jules Jean Messéan and M. Francois Alexis Ducoing and Mr. Hugh Brown be re-elected directors of the company.

The Right Hon. Sir Herbert Maxwell, Bart., seconded the motion, which was carried unanimously.

Mr. Jas. Tennant proposed for re-election as auditors, at a fee of £300, Messrs. Alex. Moore and R. C. Mackenzie.

Mr. Jas. C. Donald seconded the motion, which was unanimously agreed to.

ESPERANZA COPPER & SULPHUR CO., LTD.

Directors: G. Mure Ritchie (*Chairman*), Alexander McNab, T. D. Lawther (*Managing Director*). *Secretary:* T. D. Lawther. *Office:* 65, London Wall, London, E.C. *Formed* 1906. *Capital:* £350,000.

Business: Operate a pyrite mine in the south of Spain.

The annual general meeting of the Esperanza Copper & Sulphur Co., Ltd., was held on April 30 at Winchester House, London, E.C., Mr. G. Mure Ritchie (the Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts for 1917, said that the balance at the credit of profit and loss account carried to the balance sheet was £20,367, as compared with £50,277 in the previous year. If the progress made in the first quarter of 1917 had been maintained, the profit for 1917 would undoubtedly have considerably exceeded that of 1916. Shortly after the date of the last general meeting a change took place. Shipments fell off, the rate of exchange also steadily fell, causing them heavy losses on some of the shipments they actually did make, prices of materials and stores of all kinds went up by leaps and bounds, in fact, materials, &c., became so scarce, even at the high prices, that they had to lay in larger stocks than ever at any time they had been accustomed to. All these causes steadily depleted their cash resources as well as reduced their profits. This state of affairs had continued until recently, and for some time it looked as if they would have to shut down altogether. All the pyrite companies had done their best to help each other and the Government as far as possible, and an extension of this practice in future might be possible. Arrangements had been made whereby they might carry on without actual loss in any contract. The one thing they could not arrange, however, was the matter of boats. But it was now certain that they would get a share of such boats as there were. The arrangements were calculated to enable them to earn a dividend of 5% for the current year, and they would, of course, only do this if the number of boats allocated to them was sufficient. The development work was quite good, and the tonnage of ore developed, 872,000 tons at December 31 last, which was a safe and conservative figure, was sufficient to assure their full output for the next eight years. Their cupreous ore reserves were steadily decreasing, but the prospects for sulphur ore had improved, particularly as regards the utilization of its iron value.

Mr. Alexander McNab seconded the motion, which was carried unanimously.

ARAMAYO FRANCKE MINES, LTD.

Directors: F. Avelino Aramayo (*Chairman*), Bernard Dale, L. A. Kensington, R. G. Ribon, F. J. Torrome. *Secretary:* F. H. Ings. *Office:* 148½, Fenchurch Street, London, E.C. *Formed* 1906. *Capital issued:* £597,090.

Business: Operates a group of mines in southern Bolivia yielding tin, wolfram, silver, copper, and bismuth.

The twelfth ordinary general meeting of Aramayo Francke Mines, Ltd., was held on April 30, at 148½, Fenchurch Street, London, E.C., Mr. Bernard Dale presiding.

The Chairman, in moving the adoption of the report and accounts, said he took the chair in the absence of Mr. Aramayo, who had sent his usual statement to be made to the meeting. The results of the year showed a decided improvement in the position and prospects of the company. The revenue account showed a net profit of £225,315 in Bolivia, without deducting charges in England, as against £167,557 for the previous year ended May 31, 1916. This increase was principally due to their having been able to dispose of a greater part of the stock of tin ore and to the production of silver ore and sulphide, and copper cement, which had become an important source of revenue. The total sales of black tin amounted to 2,072 tons, or £154,968, as against 1,007 tons, or £69,546, the year before, the difference of price per ton having been on an average £7. 7s. 9d. per ton better than in the previous year. The sales of wolfram amounted to 193 tons, or £27,753, as against 49·4 tons, or £6,049, in the year before, the average price realized per ton having been £21. 5s. 5d. better. The sales of copper matte increased from 18·8 tons, or £1,061, to 117·56 tons, or £2,692, but the average price per ton was reduced by £23. 11s. 5d. on account of lower quality and fall in the price of copper. The sale of silver sulphides amounted to 242,591 oz. or £35,102 as a new source of production, and 51,221 oz. in 174½ tons of silver ore, which produced £8,072 as against £8,296 in the previous year. The sales of bismuth were not quite as important as in the year before, but the average price was maintained a little higher, although not sufficient to compensate for excessive cost of transport and insurance. The production of black tin at the mines amounted to 2,059 tons, or 35·8 tons less than in the previous year; the production of wolfram concentrates to 226·75 tons, or 78·65 tons more than in the year before; the production of copper to 48 tons, or 12 tons more. The production of bismuth was practically the same, or a third of a ton less than that of 1915-16. The production of silver in picked ore, sulphides, and copper cement amounted to 523,283·6 oz. or 413,283·6 oz. more than that reported for 1916, including 38,111 oz. contained in picked ore, which by oversight were not mentioned last year. In the first six months of the present financial year the production of black tin remained practically the same, but that of wolfram concentrates diminished by 17·5 tons on account of the low grade of the ore and the excessive compactness of the rock. The output of bismuth was a little higher and that of silver lower. He was not able to report any new finds in depth in the Chorolque tin mines, notwithstanding that very energetic work of development had been carried on, but the output from higher levels had been maintained. Active development was continued in the bismuth mine of Tasna, maintaining the reserves. Chocaya, owing to the production of silver, was a very promising concern, and during the present financial year development work had been extended over more than 400 yards in length and reached 137 yards in depth, leaving valuable ground in silver and tin standing upon three powerful veins.

Mr. Roberto G. Ribon seconded the motion, which was carried unanimously.

CHINESE ENGINEERING AND MINING CO., LTD.

Directors: F. Cattier, Chevalier E. de Wouters, E. Francqui, Edmund Davis, Colonel H. A. Micklem, Lord Southborough, W. F. Turner. *Agent and General Manager in China:* Major Walter Nathan. *Secretary:* A. W. Berry. *Office:* 22, Austin Friars, London, E.C. *Formed* 1912. *Capital:* £1,000,000; debentures £1,104,000.

Business: Owns a coal mine in Chi-li province, North China.

The fifth annual ordinary general meeting of the Chinese Engineering and Mining Company, Ltd., was held on April 29 at Winchester House, Old Broad Street, E.C., Mr. W. F. Turner presiding.

The Chairman, in moving the adoption of the report and accounts, said that since they held their last meeting in December last they had received the final accounts from China, and they had that day to submit the directors' annual report, together with the balance sheet and profit and loss account at June 30, 1917. In the profit and loss account, the first item on the credit side was their proportion of divisible net profit of the Kailan Mining Administration, £263,898, as compared with £186,183 in the previous year. At first sight this looked as if there had been a very great increase in the profits of the business conducted by the Administration, but that was not the case. Their share in the increase in the profit made in China amounted to about £24,000. The explanation of the remainder of the increase—in round figures about £54,000—was given in the directors' report, where it was stated that the profits of this company had been materially increased by the marked improvement in the rates of exchange throughout the year. Adding interest in China, less some small expenses, they had £14,154, making the total credit to the account in respect of China £278,053. Interest in London amounted to £18,788; other items amounted to £4,115, making the total credit to the account £300,958. The administration expenses amounted to £9,395, leaving a balance of £291,562. This amount was subject to provision for excess profits duty, which for the first time became a factor of importance. The excess profits duty for the preceding year amounted to £12,254. The figure for the year with which they were dealing had not yet been settled with the Revenue Authorities, but it was estimated at about £90,000. The effect of this was to absorb the whole of the increased profit of the year, which amounted to very nearly the same figure. The balance brought forward at July 1, 1916, was £162,122. Adding the year's profit which he had just mentioned gave a total of £453,685. An interim dividend of 5%, free of income tax, was paid on May 15, 1917, absorbing £50,000. Income tax to June 30, 1917, amounted to £42,031. Deducting these, there was a balance of £361,654. The balance dividend of 7½%, free of income tax, was declared on December 17 last, requiring £75,000. The cash, Treasury bills, and investments in War Loans and in Exchequer bonds amounted to £570,693. The creditors amounted to £258,397. In addition, there was the half-year's debenture interest accrued to June 30, £33,120. Nearly the whole of these liabilities were in respect of debenture interest, debentures drawn for redemption, and dividends on share capital, the amount due to creditors on sundry accounts being only £22,000. The Six Per Cent. Debentures outstanding had been reduced by the annual drawing by £24,000, and now amounted to £1,104,000. As regards the other items on the credit side of the account, there was very little change as compared with the preceding year.

As regards the working of the business of the Kailan Mining Administration, the year had been characterized by many difficulties. The chief of these had been caused by the requisitioning by the Admiralty, not only of their boats, but also of their long-time charter boats. Another serious difficulty had been the shortage of cars on the North China railways. These difficulties were not peculiar to themselves; the shortage of steamers and of railway cars existed practically throughout the world. That their difficulties had been met in a most able manner by Major Nathan, their general manager, was proved by the fact stated in the report that the sales for the year amounted to 2,766,873 tons, which was an increase in round figures of 100,000 tons over the preceding year. As regards the current year, of which nearly ten months had elapsed, the same difficulties existed, and, indeed, had been accentuated. Nevertheless, the sales had not only been maintained to date, but had increased, and that notwithstanding some interference with the Administration's trade caused by the extensive floods in the Tientsin district. The rate of exchange also had been well maintained, and as there were only two months of the financial year yet to run, they thought they might safely count upon the result of this present year being at least equal to that with which he had been dealing. The work of development in the mines proceeded as usual throughout the year, the coal in sight at June 30, 1917, being reported at nearly 16,000,000 tons. There were two other matters which he had to mention. They much regretted to have to report the death of their late colleague Mr. Symons, who was an original director of this company and of its predecessor. They were pleased to report that the vacancy had been filled by the appointment of Lord Southborough, whose election would be submitted for confirmation. Since the outbreak of the war they had from time to time voted various sums in support of war charities, and they had to report that a sum of £2,000 had recently been voted for this purpose. The amount had been allocated to the British Red Cross, the Belgian Relief Fund, the Seamen's Hospital, and the Middlesex Hospital, and would appear in the accounts for the current year. An interim dividend of the usual amount of 5%, free of income tax, had been declared that day in respect of the current year and would be payable on May 15.

The Right Hon. Lord Southborough, G.C.B., seconded the resolution, which was carried unanimously.

The election of Lord Southborough as a director was confirmed, and Mr. Félicien Cattier and the Chevalier E. de Wouters, the retiring directors, were re-elected on the motion of the Chairman, seconded by Mr. Edmund Davis.

Messrs. Annan Dexter and Co. were re-appointed auditors on the proposition of Mr. H. Sledge, seconded by Mr. A. Caro.

The proceedings then terminated.

PLYMOUTH CONSOLIDATED GOLD MINES, LTD.

Directors: David Richards *(Chairman)*, John Barry, W. J. Loring, C. A. Moreing. *General Managers:* Bewick, Moreing & Co. *Secretary:* T. E. Smith. *Office:* 20, Copthall Avenue, London, E.C.2. *Formed* 1914. *Capital:* £240,000.

Business: Operates a gold mine in Amador County, California.

The fifth ordinary general meeting of the Plymouth Consolidated Gold Mines, Ltd., was held on May 7 at 20, Copthall Avenue, London, E.C., Mr. David Richards (the Chairman) presiding.

The Chairman, in moving the adoption of the report and accounts for 1917, said that the results compared favourably with, but were not quite up to, the level of the two preceding years. The output amounted to 127,750 tons, against 125,000 tons and 129,500 tons respectively for the two previous years. An average value of 22s. 0·40d. per ton was obtained, as compared with 22s. 5d. for the preceding year and 20s. 7d. for 1915. Costs, however, were slightly up on 1916, and 1s. 8d. per ton above 1915. American war taxation had also come very promptly against them upon the United States entering into the war. In spite of these adverse circumstances, they had a profit of £34,000 from the year's working, or about £8,000 below that of the year before. The position and prospects at the mine were quite good. Development had been carried on energetically in the higher levels going south and also at the lower levels, the 2,150, 2,300, and the 2,600 ft. levels, the last being the bottom level opened out. Development work at these levels had been directed toward exploring to the north of the shafts. Last year, driving north on the 2,150 ft. level, they discovered a new ore-body of good width giving excellent values. This ore-body had during the year been located and opened out on the level above. It had also been proved to extend downward on the 2,300 ft. level, where at points it gave a great stoping width of 26 ft. of highly profitable ore. At the 2,600 ft. level fair values had been also opened out, and a second shoot, believed to be a branch of the main lode, had been disclosed. They had driven 100 ft. odd and it had an average value of 35s. for a good width. These discoveries in the bottom levels north had considerable importance and bearing upon the future of the mine in depth, and there was every reason for believing that, as they were developed and opened out, they would yield a large tonnage of ore going well above the average milling grade. At the higher levels south very considerable development work had also been continued during the year, with excellent results, on the middle and south shoots, particularly on the 1,200 ft. and the 1,400 ft. levels. The 1,200 ft. main south drive had exposed two profitable ore shoots, giving higher values than the average of the mine. Since the end of last year the 1,400 ft. main south drive had been further advanced and continued to develop some excellent values, much of it going 60s. over a width of 60 in. This seemed to be the downward extension of the ore-body opened out in the 1,200 ft. level. The outlook as regards the mine was undoubtedly quite good, and, provided fair conditions were given, they need have no doubt about the future. This company so far had amply fulfilled all its early promise. Since August, 1914, when they began crushing, with the 1s. dividend which they hoped to declare at the end of the current month, they would have paid back to shareholders dividends amounting to 50% of their capital.

The motion was seconded by Mr. John Barry, J.P., and carried unanimously.

THE MUREX COMPANY, LIMITED.

Directors: G. P. Joseph (*Chairman*), Edmund Spyer, David Anderson. *General Manager:* H. A. Green. *Secretary:* W. Weir. *Office:* 1, London Wall Buildings, London, E.C.2. *Formed* 1913. *Capital issued:* £56,643 in 5s. shares.

Business: Owns the Lockwood-Samuel patents for the Murex wet magnetic concentration process, and conducts separation operations on this system; produces ferro-tungsten and tungsten powder.

The fifth ordinary general meeting of the Murex Company, Ltd., was held on April 29 at Salisbury House, London, E.C., Mr. George P. Joseph (the Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts, said that they were meeting to recommend the declaration of their first dividend. Their receipts from royalties on ore treatment and ore purchases account amounted to £31,024, as against £16,124. The net result was that, after charging all expenditure and making allowance for depreciation, the profit was £15,868, which was nearly double that of the previous year. At the time of the meeting last year their business was chiefly confined to the separation of wolfram and tin ores and the treatment of complex tungsten ores. Toward the end of last year they were placed by the Ministry of Munitions on its list of recognized tungsten manufacturers. Since then they had received from the Ministry a proportion of all the wolfram ores coming to this country for the manufacture of tungsten, and they had every reason to believe that the tungsten manufactured by the company compared very favourably with that of other makers. Those results were due to the knowledge, energy, and perseverance displayed by their general manager, Mr. H. A. Green. Additional premises and works were purchased by the company last year, consisting of freehold property situated in Essex, on the river, where they had their own jetties, etc., affording facilities for the economical handling of ores, coal, stores, etc. The plant was working very satisfactorily, and they were turning out tungsten of exceedingly good quality. They were still operating their two other works to their full capacity. They had supplied their products to thirty-eight makers of high-speed steel, and the purity of the material supplied by them was above the standard laid down by the Ministry of Munitions. He believed that their products had now been delivered to practically every firm in the United Kingdom using tungsten. The directors had entered into certain arrangements, to become effective after the war, relating to the treatment of tungsten ores, which they believed would lead to profitable results.

Mr. David Anderson seconded the motion and it was carried unanimously.

GURUM RIVER (NIGERIA) TIN MINES, LTD.

Directors: Oliver Wethered (*Chairman*), H. S. Foster, H. C. Godfray. *Secretary:* E. J. Andrews. *Office:* 54, New Broad Street, London, E.C.2. *Formed* 1911. *Capital issued:* £110,303. 10s. in shares of 10s. each.

Business: Operates alluvial tin properties in Northern Nigeria.

The annual general meeting of the Gurum River (Nigeria) Tin Mines, Ltd., was held on May 8, at Winchester House, London, E.C., Mr. Oliver Wethered (Chairman of the company) presiding.

The Secretary (Mr. E. J. Andrews) having read the notice convening the meeting and the report of the auditor,

The Chairman said that as he was still suffering from the effects of his old attack of pneumonia, he had prepared some notes which he would ask his colleague, Mr. Godfray, to read.

Mr. Hugh C. Godfray read the following: "To those shareholders who were connected with the company in its early days and who remember the bitter disappointments which attended its early operations the position as shown in the report will be very gratifying. To me, the only one of the original directors, it is a source of deep satisfaction, for I have devoted an immense amount of time and have assumed heavy responsibilities in assisting to bring the company to its present condition. The very valuable assistance given by the Niger Company and the co-operation of other good and powerful friends has placed us on the high road to success, I believe great and permanent success. The results obtained from our property up to September 30, and the very substantial returns since indicate that Messrs. Laws, Rumbold and Co. are getting the property into something approaching ship-shape, and we have sanctioned some special expenditure with a view to increasing the water supply, which would mean increased power of production. A little later I hope to give you further details of the developments, but I think we may anticipate with considerable confidence good returns for several years. Meanwhile we have been looking in other directions to increase our interest in properties of merit, with good conditions for working and big possibilities, and I am glad to say that we have acquired a half-interest in areas one of which is producing a substantial monthly tonnage of concentrates at a good profit. With our co-owners, we have authorized the equipment of a second area, where 10 tons per month may be looked for at no distant date, and the remaining areas will be worked as soon as possible. Our partners in the business are very powerful, and I am satisfied that we shall receive further co-operation in this direction.

"This deals with our Nigerian interests, but we have been interested for a considerable time in Cornwall, with the tin-mining industry of which county I have been so long connected, and so, too, has my colleague, Mr. Godfray. We took part in providing East Pool with working capital and realized considerably over 100% profit on our investment. We have a small interest—which I hope will later on be increased—in the Geevor mine, one of the best properties in the county, and we have a larger interest, with power to materially increase it, in the Porkellis Tin Mines, Ltd., where over 100,000 tons of ore have been developed and the production of tin has just started. I ventured some years ago to express the view that owners of purely alluvial properties would do well to invest some part of their profits or resources in acquiring lode properties in Cornwall, with a view to developing large tonnages of ore for future working. This view has been adopted by some companies, and more powerful undertakings have it in contemplation. Meanwhile the wonderful developments on the East Pool mine, and the highly satisfactory developments on the South Crofty, Geevor, Porkellis, and Tresavean mines, are justifying the faith some of us have expressed in the future of the Cornish tin lodes. In saying this let me make it clear that my faith in the future of Nigeria in now greater than ever. On the Rayfield, the Bauchi, and the Mongu, to mention three of the companies with which I am connected, we are finding new sources of supplies at depth, which would be as surprising as they are gratifying were it not that one is wise to be prepared for any development in that most interesting field. The all-important question of the price of tin is always one to approached with caution, and especially so at this time. We can hardly expect, or indeed desire, the present figure to continue indefinitely, but in my opinion we may look with very considerable confidence to prices ranging from £250 to £300 for many years. The cost of production has increased very greatly and the exhaustion of the more accessible alluvials is a question of time. What I do earnestly hope is that the Government will never lose sight of the fact that tin within the British Empire is a national asset of enormous value."

The Chairman then said: Gentlemen, there is very little for me to add, but I think you will arrive at the conclusion, from a remark made in the report and from hearing what Mr. Godfray has been good enough to read, that we are within reasonable sight of dividends. In that connection it is distinctly interesting to know that our sorrows of the past are going to give us some compensation in the future, for our lean years vis-à-vis the excess profits duty will have the effect, so we are advised by our auditor, that we shall be able to pay nearly 40% on our capital before we are liable to make any contribution to the Government in respect of excess profits duty. That tax has been the subject of much discussion. It is obvious to everybody that it is doing a great deal of injury to enterprise, and I long for the day when it will be removed and give people a chance of carrying on business without always fearing to do the very best for their shareholders. That is really what it amounts to. But happily in this case the incidence of that tax is not as bad as it might be, and, as I have told you, we can pay very substantial dividends before we suffer. I beg now formally to move: "That the report of the directors and statement of accounts to September 30, 1917, now submitted to this meeting, be and the same are hereby adopted."

Mr. Godfray seconded the motion, which was unanimously adopted without discussion.

CHAMPION (NIGERIA) TIN FIELDS, LTD.

Directors: S. R. Bastard (*Chairman*), F. N. Best, John Waddington. *Consulting Engineer in Nigeria:* R. W. Hannam. *Secretary:* A. J. Culley. *Office:* Friars House, New Broad Street, London E.C.2., *Formed* 1909. *Capital:* £50,000 in shares of 5s. each. *Business:* Has floated a number of Nigerian tin companies; also works an alluvial gold deposit.

The seventh ordinary general meeting of Champion (Nigeria) Tin Fields, Ltd., was held on May 9, at Winchester House, London, E.C., Mr. Segar R. Bastard (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts, pointed out that the investments stood at £26,464. As to the profit and loss account, their management expenses were not high, and in regard to the gold sales those were 1,661 oz. at £3. 10s. per ounce. Turning to the report, he said that the Naraguta Extended Tin Mines Company had done exceedingly well, and in regard to the Tin Fields of Northern Nigeria he had reason to believe that the property was not a bad one. The Berrida (Nigeria) Tin Fields, Ltd., held a lease adjoining the Naraguta Extended Tin Mines, on which there was reported to be plenty of tin, but it was very deep ground.

In regard to the Poldice mine, in Cornwall, he had been able to secure that for the Berrida Company at a very reasonable price, and the more the property had been investigated the more certain were the Board that it was a valuable one. It was an old mine, from which large quantities of tin and copper had been produced in the past. The main feature of the property was that there was an extensive dump, consisting of tin and wolfram. Anyone going to Poldice could not help being struck by the large amount of stone carrying visible wolfram which had been left there. It was estimated that there were between 1,000,000 and 2,000,000 tons available giving, as far as could be ascertained, an average of 20 lb. of tin and wolfram to the ton in about equal proportions. At the present prices of those metals it was undoubtedly an excellent commercial proposition, without any of the ordinary risks of mining. The stuff was ready for them, and they had only to work it economically and cheaply. That was the policy the Board had decided on. It was a most interesting proposition, because, if the plans of the old workings were examined, it would be seen that an immense amount of work had been done, shafts sunk and numerous lodes driven upon, a good deal of ore having been stoped out. That led one to believe that it was left because of the quantity of wolfram which it contained. They could break off stone containing visible wolfram, which at the present price of the metal would pay very well to take to the batteries. They had had the good fortune to obtain at a reasonable price a big plant from a neighbouring mine. This would enable them to start the production of tin, wolfram, and arsenic on a very large scale, and they were aiming at treating 350 tons a day. They had made a very interesting discovery on the battery site. That site had been cleared on the side of a hill, and they found it necessary to excavate another 3 ft. into the hill in order to make room for the battery. While doing that they struck a very fine lode of wolfram. The fact of their striking that new lode was eminently satisfactory, and he could not help thinking that as the Government was in great need of wolfram some pressure would be brought to bear to have the mine worked as it should be. The directors had received a highly favourable report from Mr. W. Morley Martin in regard to the prospects of the Poldice property. With reference to working capital, he was satisfied that the money they had in hand would prove sufficient to bring the property to the producing point.

The Chairman then referred to the Lucky Chance Company. This company had been able to acquire, through his instrumentality, a Cornish property which adjoined the Poldice and was known as the West Poldice. It was a shallow mine, the deepest part being only 600 ft., which was not anything in Cornish mining. Above the adit level there were large amounts of ore standing, as in Poldice, and for the same reason that a considerable amount of wolfram existed in the lode they were left intact. Wolfram to-day was of five times as much value as tin was when these mines were abandoned, so that it now became a very payable proposition. Wolfram, he would remind shareholders, was now of the value of £200 per ton. The engineer who was now managing the Poldice, had been down to West Poldice, and he estimated that there was something like 100,000 tons standing above the adit level there, so that it was a very valuable proposition. The question of working it involved a large amount of capital. The Lucky Chance was now simply engaged in proving the existence of large quantities of ore above the adit level, and was treating some of the ore. There were nine small water-driven stamps, and these were giving excellent results, and enabling the engineers to thoroughly sample the mine. He was quite sure that the work of the company would call such attention to that corner of Cornwall as would enable them to obtain adequate working capital.

With regard to the gold areas in Nigeria, they, as he had already said, had been very disappointing, but at any rate they were more than paying expenses, and by doing that the company had a chance of finding some valuable gold ground. In conclusion he desired to say that the company was now in a far stronger financial position than it had ever been before, and they were quite capable of undertaking fresh enterprises. He had little doubt that if they thought fit and good terms could be obtained he could arrange with the Berrida Company for their company to take a portion of Poldice, which was such a gigantic concern that there was room for many companies on that alone.

Mr. Robbins seconded the resolution and it was carried unanimously.

On the motion of the Chairman, seconded by Mr. F. N. Best, Mr. John Waddington was re-elected a director, and on the motion of Mr. Robbins, seconded by Mr. C. S. Jones, Messrs. Newman Ogle, Son & Grace were re-appointed auditors.

Mr. Best proposed a vote of thanks to the Chairman, who, he said, had put in much hard work for the company. It was not long since the company had only a poor prospect, but by going into Cornwall in this way, the Chairman had made it a very flourishing concern.

The Chairman acknowledged the vote, and the meeting separated.

THE CONSOLIDATED MINES SELECTION COMPANY, LTD.

Directors: Walter McDermott (*Chairman*), Robert James Frecheville, Frederick William Green, Louis Oppenheimer. B. Kitzinger and J. S. Wetzlar (*Managing Directors*). *Consulting Engineer:* C. E. Knecht. *Secretary and Head Offices:* C. W. Moore, 5, London Wall Buildings, London, E.C.2. *Johannesburg Branch Office:* The Corner House, Johannesburg. *Managing Director:* F. R. Lynch. *Local Secretary:* J. H. Gratton. *Formed* 1897. *Capital issued:* £552,500, in 1,105,000 shares of 10s. each.

Extracts from the Report for the Year Ended December 31, 1917.

The issued capital of the company remains unchanged, £552,500 in 1,105,000 shares of 10s. each, fully paid. The amount of debentures outstanding at December 31 last was £96,250. This has since been further reduced by the redemption on January 1, 1918, of £6,060 debentures drawn for repayment, and now stands at £90,460. The accounts submitted show a profit of £173,461. 9s. 2d., including the sum of £9,215. 11s. 10d. brought forward from last year. The directors—as previously announced—recommend the payment of a dividend of 30% leaving, subject to further remuneration to directors and managing directors in London and Johannesburg, a balance of £29,148. 19s. 2d. to be carried forward. The financial position of the company has been further strengthened: cash and cash assets, as on December 31 last, exceed current and contingent liabilities by £340,595. Properties and unquoted securities, as valued by the directors, stand in the books at £47,010. 15s. 9d.; while quoted securities taken at cost or under, but in no case higher than the market price at December 31, 1917, amount to £588,314. 14s. 9d.; total £635,325. 10s. 6d. These quoted securities, if taken at prices ruling at December 31, 1917, would show a very substantial increase over their valuation on the books.

The net profit for the year amounts to		£164,245 17 4
arrived at as follows:		
Net Profits realized on Sales, Commissions, &c.		£98,876 1 4
Interest and Dividends		87,944 16 6
Transfer Fees		288 19 0
		£187,109 16 10
against which had to be written off:		
Expenses, &c.	£4,179 14 4	
Debenture Interest	4,826 0 0	
Cost of Investigations, Claim Licences, depreciation of Office Furniture, &c.	2,669 0 8	
Income Tax London, and Taxes Johannesburg	11,189 4 6	
		22,863 19 6
		£164,245 17 4

By the allotment of a further 26,100 shares issued during the year 1917 at £5 per share, under the arrangement fully set forth in the last annual report, the issued capital of Brakpan Mines, Limited, has been increased to £786,100. Reduction operations during 1917 gave the following results: tons treated 677,500, recovery per ton 34s. 6d., costs per ton 20s. 3d., profit per ton 14s. 3d., as compared with 709,300 tons, 30s. 11d., 19s. 3d., and 11s. 8d. for 1916. Both yield and profit per ton are records for any year in the history of the mine. Further information is given in the Brakpan Mines Ltd. report.

The most important event of the year, not only for this company, but for Springs Mines Limited, has been the success in obtaining from the Government of the Union of South Africa the lease of an area equal in extent to 2,236 claims, which added to 1,332 the previous extent of the Springs company's mining rights, makes the mining area now 3,568 claims. The company secured this lease in the face of active competition, and by reason of advantages which could be offered in its immediate development through the Springs Mines. This acquisition only became possible owing to the arrangements made by this company and its associates for raising the necessary capital, the agreement involving the issue of altogether 500,000 shares at £3 per share free of commission. Of these 100,000 were to be issued immediately on the signing of the lease agreement, the proceeds to be earmarked for working capital in connection with the lease ground, 100,000 to be issued as occasion arises in connection with the repayment of the company's debenture issue of £314,950, and the remaining 300,000 shares as and when required for the provision of further working capital. South African shareholders in Springs Mines were offered the right to subscribe for one new share at £3 per share in respect of every 10 shares held, but as the necessary Treasury consent for which the company applied was refused, the same privilege could not be extended to shareholders on the London Register.

Information relating to Daggafontein Mines, Ltd., and Rand Selection Corporation, Ltd., is given in the reports of these companies.

The capital of New Era Consolidated, Ltd., remains £100,000 in 400,000 shares of 5s. each. There is no change in its claim holdings, while as regards shareholdings there has been further concentration on Far Eastern Rand stocks. The company continues to participate in the financial operations of the Consolidated Mines Selection Company, Limited, and now has substantial holdings both in Brakpan and Springs shares. A dividend of 12½% was paid for the year 1917.

The directors are pleased to state that, apart from some interest in the Russian Mining Corporation, Limited, the company has disposed of all its Russian mining interests at a profit.

The company's interest in the Burma Corporation is represented by its holdings in shares of the Bawdwin Syndicate, which remains unchanged. The development of the Bawdwin Mine has continued to give excellent results, and a very great tonnage of high grade lead, silver, zinc ore has been put in sight. The large outlays necessary for the continued equipment of mill, railway, and reduction works will prevent any returns from dividends for some time to come, but in due course the property is certain to prove most profitable.

The West African Mines Selection Syndicate, Ltd.'s main interest consists of shares in the Wallis Company, Limited. Work on that property proceeded throughout the year without, however, leading to any material improvement in the outlook.

The Itabira Iron Mine is a most promising property; but its value is a future one, requiring a large organization of the mining, railway, and shipping departments before any results can be obtained. The holdings of this company in the Itabira Iron Ore Company and the B. H. Syndicate, its parent concern, have been increased during the year.

RAND SELECTION CORPORATION, LIMITED.

(Incorporated in the Transvaal.)

Directors: F. R. Lynch (*Chairman*), J. H. Gratton, H. S. Johnson Hall, W. E. Hudson, C. Marx, E. Oppenheimer, F. G. C. E. Robellaz, W. S. Saunders, G. Sonn. ***London Committee***: B. Kitzinger, J. S. Wetzlar, F. W. Green. ***Secretaries***: The Consolidated Mines Selection Company, Ltd. ***Consulting Engineer***: C. E. Knecht. ***Head Office***: The Corner House, Johannesburg. ***London Office***: 5, London Wall Buildings, E.C.2. ***Formed*** 1889 as the Transvaal Coal Trust Ltd.; name changed in 1916. ***Capital***: £550,000, in 550,000 shares of £1 each, fully paid and issued.

EXTRACTS FROM THE 26TH ANNUAL REPORT FOR THE YEAR ENDED DEC. 31, 1917.

The capital of the corporation is unchanged at 550,000 shares of £1 each, fully paid and issued. Several items, standing in the property account at £20,101. 4s. 9d., were included in the sale of the corporation's coal assets to Tweefontein United Collieries, Ltd., and have consequently disappeared from the balance sheet. The interests acquired by the corporation in the Schapenrust claims and the New Geduld Deep mynpachts at a cost of £28,587. 18s. 11d. are included in the property holdings. During the year a number of stands have been disposed of, selling for £117,475, and the net receipts were £51,931. 14s. 9d. When the establishment of Brakpan Township was originally approved of in 1911, the Government reserved its decision in respect of a block of 463 stands (which had been surveyed and was intended to form part of the Township), having in view the possibility of the ground eventually being required for mining purposes. The directors have now satisfied the authorities that the occupation of 423 of these stands will not cause any interference to mining, and the restriction upon the sale thereof has been removed. In accordance with the conditions attached to the grant of permission to establish the Township, an endowment of 10% of the new stands was ceded to the Benoni Municipality. The net amount received by your corporation in 1917 on account of Springs Township, after allowing for all outgoings, was £14,388. 9s. 4d. The asset has been written down to £1, and the balance of £8,680. 13s. transferred to profit and loss account.

Information relating to Brakpan Mines, Springs Mines, and Daggafontein Mines is given in the reports of those companies.

In terms of the agreement with the Consolidated Mines Selection Company, Ltd., your corporation acquired a participation of 25% in the purchase by that company from the New Geduld Deep, Ltd., of Mynpachts Nos. 514 and 525, situate on the Farm Geduld No. 24, representing together an area of 172·4 claims. The consideration payable by your corporation for this interest was agreed upon at £13,400 (representing the value, at the time the transaction was completed, of 4,375 shares in Springs Mines, Ltd.). In addition, the New Geduld Deep, Ltd., was granted the right to participate in subscribing to the working capital of any gold mining company to which the property may hereafter be ceded, and in which the Consolidated Mines Selection Company, Ltd., may acquire an interest. Should these contingencies occur, your corporation will be liable for its *pro rata* of this right.

Your corporation duly took up 2,500 shares in the Industrial Development Company Ltd. venture, upon which 11s. per share had been paid at the end of the year.

At the last annual general meeting the Chairman stated that negotiations were proceeding for the sale of the corporation's coal assets. These negotiations, which were with Henderson's Transvaal Estates, Ltd., resulted in the disposal of the whole of our coal interests, as a going concern, to a new company named Tweefontein United Collieries, Ltd., with effect from September 1, 1917. The ultimate consideration received for these assets was as follows: 63,780 fully paid £1 shares in Daggafontein Mines, Ltd., 25,000 fully paid £1 shares in Daggafontein Gold Mining Company, Ltd., and £45,000 in cash. The output of coal from Oogies Colliery for the period January 1 to August 31, 1917, was 332,367 tons, and the profit from coal mining amounted to £13,260. 15s. 4d.

The Profit from Coal Mining was		£13,260 15 4
Dividends on Shareholdings and Schapenrust Claims Revenue		123,115 16 7
Brakpan and Springs Townships		46,223 18 5
Nett Profit realised from Sales of Shares, etc.		7,345 2 4
Interest, Sundry Revenue, etc.		5,738 9 8
		£195,684 2 4
Deduct—		
General Charges and Contributions to War Relief Funds, etc.		11,428 4 5
Nett Balance to Credit of Profit and Loss Account		£184,255 17 11
Add—		
Balance to Credit of Appropriation Account, 31st December, 1916		58,582 6 7
		£242,838 4 6
The following amounts have been appropriated:—		
Government Taxes	£2,794 11 4	
Dividend Nos. 35 and 36 (30 per cent).	165,000 0 0	
		167,794 11 4
Unappropriated Balance, 31st December, 1917		£75,043 13 2

Your directors recommend that the following interim dividends, which have already been paid, be declared the dividend for the year 1917: No. 35 of 12½% £68,750, No. 36 of 17½% £96,250. You will be asked to confirm the appointment of Mr. W. E. Hudson as a director of the company. In accordance with the articles of association, Messrs. J. H. Gratton and G. Sonn retire from the board by rotation, but are eligible and offer themselves for re-election. You are requested to fix the remuneration for the past audit and to elect auditors for the ensuing year. The auditors, Messrs. Alex. Aiken and A. E. Page, retire, but are eligible and offer themselves for re-election. At the instance of the Union Treasury, an Order of Court has been granted vesting in the Custodian of Enemy Property 126,380 shares in your corporation belonging to enemy shareholders.

BRAKPAN MINES, LIMITED.

(*Incorporated in the Transvaal*).

Directors: F. R. Lynch (*Chairman*), H. S. Johnson Hall, C. Marx, H. Newhouse, E. Oppenheimer, E. Renaud, W. S. Saunders. *London Committee:* F. W. Green, Egerton H. E. Hensley, Sir Frederick Frankland, Bart. *Secretaries:* The Consolidated Mines Selection Company, Ltd. *Consulting Engineer:* C. E. Knecht. *General Manager at Mine:* C. R. Davis. *Head Office:* The Corner House, Johannesburg. *London Office:* 5, London Wall Buildings, E.C.2. *Capital:* £850,000, in 850,000 shares of £1 each, of which 63,900 are unissued.

EXTRACTS FROM THE 15TH ANNUAL REPORT.

For the Year ended December 31, 1917.

The mineral lease entered into between the Union Government and your company in respect of the Brakpan government mining area was duly completed and signed on July 24 last, with effect from January 1, 1917. During 1917 the right to take up 26,100 shares at £5 each was exercised, thereby increasing the issued capital of the company to £786,100, in 786,100 shares of £1 each, fully paid. The balance of 63,900 shares remains to be issued in accordance with the provisions of the agreement with the Consolidated Mines Selection Company, Ltd., dated October 20, 1916.

From the working expenditure and revenue account it will be seen that the profit from operations for the year amounted to £482,120. 1s. 0d. Deduct additional war charges on gold realization £10,947. 17s. 3d. and war relief funds and donations £2,963. 2s. 4d. and adding interest, dividends on shareholdings, estate and sundry revenue £6,221. 19s. 3d. leaves a net balance of revenue over expenditure for the year of £474,431. 0s. 8d. Against this the following amounts have been appropriated: Government taxes £62,735. 19s. 9d., participations in profits £28,129. 10s. 3d., dividends Nos. 11 and 12 £367,525.

Capital expenditure for the year amounted to £163,294. 7s. 11d., of which shaft sinking and equipment accounted for £139,369. 5s. 4d. The value of stores and materials on hand at the end of the year amounted to £149,189. 3s. 3d., an increase of £103,923 1s. 10d. over the corresponding figure for 1914. The increase is due mainly to exigencies arising out of the war. The sum of £10,459. 16s. 10d., representing the amount by which the fixed charge for development debited to working costs exceeded the actual cost, has been carried forward under the heading "development suspense account." The Union Government's 5% participation in the profits of the company under the Mineral Lease, which took effect as from January 1, 1917, is estimated at £23,066. 4s., while the percentage of profits due under the Schapenrust claims purchase agreement is estimated at £5,063. 6s. 3d., being 18/82 of the amount payable to Government. The unappropriated balance of profit carried forward has been increased by £16,040. 10s. 8d. Two dividends have been declared during the year: No. 11 of 22½% on the issued capital of £760,000, absorbing £171,000; No. 12 of 25% on the issued capital of £786,100, absorbing £196,525, total £367,525. At the instance of the Union Treasury, an Order of Court has been granted vesting in the Custodian of Enemy Property 58,641 shares in your company belonging to enemy shareholders. At the end of the year 86 of the company's employees, representing about 18% of the total average number of Europeans employed, were on active service in Europe and in German East Africa.

EXTRACTS FROM THE CONSULTING ENGINEER'S REPORT.

The tonnage milled totalled 677,500 tons, which is less by 31,800 tons than that dealt with during 1916. The average yield was 34s. 5·9d., working costs averaged 20s. 3·1d., and the working profit 14s. 2·8d. per ton milled. The yield, when compared with that of the previous year, was 3s. 6·5d. higher, working costs were 11·5d. higher, and working profit 2s. 7d. higher. Total working profit amounted to £482,120, from which must be deducted £10,948, being the additional cost of gold realization due to the war, leaving a net working profit of £471,172. The increase in net working profit over that earned during 1916 is £68,264.

Development work accomplishment totalled 18,451 ft., of which 13,565 ft. were on reef averaging 8·69 dwt. over 46.08 in. The payable ore reserve as at the end of the year is estimated at 3,268,000 tons, of an average assay-value of 9·2 dwt. per ton over an average stoping width of 67 in. This estimate shows an increase of 214,000 tons over the estimate at the beginning of the year, and a decrease of 39,000 tons when compared with the reserve at June 30, 1917. The assay-value remains unchanged. The small decrease in tonnage is due to the elimination on account of increased working costs of a large tonnage of low-grade ore which, under present circumstances, cannot be regarded as payable. For this reason and also on account of the restrictions as to glycerine supplies, it will be necessary to discontinue drawing upon this ore for the mill. It is probable, therefore, that the rate of tonnage production during the current year will be upon a somewhat lower standard than during 1917. It will be possible to replace to a considerable extent the low-grade tonnage by ore of higher grade, and it is anticipated that the monthly profits will thereby be maintained unless further excessive increases in working costs or shortage of essential supplies makes this impossible.

Work on No. 3 and No. 4 circular shafts, situated on the lease area, has proceeded during the year. The sinking equipment at No. 3 shaft is complete, with the exception of the direct winder, and the total depth of the shaft at the end of the year was 196 ft., of which 147 ft. were bricked. On February 8 last an inflow of water was met with at a depth of 330 ft. It is expected that sinking will be temporarily interfered with pending steps now being taken to deal with the water. The sinking equipment at No. 4 shaft is now practically complete, and at the end of the year the depth of the shaft was 160 ft. The major extensions to the reduction plant, bringing its nominal capacity up to 75,000 tons monthly, were completed during the year, but the exceedingly wet weather during recent months made it advisable to postpone the work on certain tank foundations. This work is now in progress.

SPRINGS MINES, LIMITED.

(Incorporated in the Transvaal.)

Directors: F. R. Lynch (*Chairman*), H. S. Johnson Hall, W. L. Honnold, C. Marx, H. Newhouse, E. Oppenheimer, W. S. Saunders. *London Committee:* F. W. Green, C. W. Moore, C. T. Pott. *Secretaries:* The Consolidated Mines Selection Company, Ltd. *Consulting Engineer:* C. E. Knecht. *Manager at Mine:* B. D. Bushell. *Head Office:* The Corner House, Johannesburg. *London Office:* 5, London Wall Buildings, E.C.2. *Formed* 1908. Authorized Capital £1,500,000; Issued Capital £1,000,000; Debenture Issue £314,950.

EXTRACTS FROM THE 9TH ANNUAL REPORT FOR THE YEAR ENDED DEC. 31, 1917.

At extraordinary general meeting of shareholders, held on May 25, 1917, and June 18, 1917, respectively, a resolution was passed and confirmed authorizing your directors to increase the capital of the company from £1,000,000 to £1,500,000. During the year under review the option on 44,000 shares held in reserve was exercised, thereby increasing the issued capital of the company to £1,000,000 in 1,000,000 shares of £1 each, fully paid. The debenture issue remains unaltered at £314,950.

A circular was issued on November 3, 1917, informing shareholders that the Union Government had provisionally accepted the company's tender for the lease of the mineral rights of the eastern portion of the Farm De Rietfontein No. 14 (comprising an area of 2,236 claims) on the basis of an amalgamation with Springs Mines. Details of the financial arrangements and the proposed scheme for working the combined area were given in the circular mentioned and in a further circular issued on January 23, 1918. The lease agreement was duly completed and signed on January 17, 1918, with effect from January 1, 1918.

The total funds provided and the expenditure incurred to complete the original plant are as follows:

EXPENDITURE.

Property Transfer duty ...		£7.761 7 2	
Shaft Sinking and Original Equipment ...	£1,175,542 14 2		
Estimated Amount required to complete Original Equipment ...	4,456 1 0		
		1,179,998 15 2	
Development to date of crushing		206,093 13 0	
General and Administration Expenses to date of crushing ...		94.829 18 2	
Debenture and Loan Charges, and Interest to date of crushing		121.750 6 8	
			£1,610,434 0 2

RECEIPTS.

330,000 Working Capital Shares at 30s.	£495,000 0 0	
370,000 Shares issued at par ...	370,000 0 0	
Debenture Issue: £314,950 issued at £97½%	307.076 5 0	
Interest Received and Sundry Revenue to date of crushing...	87.464 18 1	
		1,259,541 3 1
Leaving an excess of Expenditure over Receipts of...		£350,892 17 1

Against this shortage the profit earned to December 31, 1917, amounted to £214,953. 16s. 3d.

The item £94,829. 18s. 2d., "general and administration expenses to date of crushing," has been allocated over the main asset accounts as follows:

Expenditure on Shaft Sinking, Permanent Haulage Ways and Equipment	£79,616 0 0
Development	15,213 18 2
	£94,829 18 2

The expenditure on debenture and loan charges and interest, together with the discount on debentures, and interest and sundry revenue received to date of crushing, have been dealt with in a separate revenue and expenditure account, the balance of which has been written off premium on shares account.

From the working expenditure and revenue account it will be seen that the profit from operations amounted to £264,442. 0s. 6d. Deduct additional war charges on gold realization £5,730. 19s. 5d., and debenture and loan interest, and war donations since the commencement of production £34,396. 17s. 8d., leaving a net balance of revenue over expenditure for the period of £224,314. 3s. 5d. against which has been appropriated Government taxes amounting to £9,360. 7s. 2d.

EXTRACTS FROM THE CONSULTING ENGINEER'S REPORT.

The total tonnage milled, including the trial crushing, amounted to 313,065 tons; the average yield was 39s. per ton, working costs averaged 22s. 1·2d., and working profit 16s. 10·8d per ton milled. The working profit for the period totalled £264,442, from which must be deducted additional gold realization charges due to the war amounting to £5,731, leaving a net working profit of £258,711. The yield was adversely influenced by abnormal circumstances incidental to starting, the more important factors being the absorption of gold by the plant and the inclusion during the early months of milling of 38,275 tons of low-grade ore from the development dump. Working costs, aside from being subject to the abnormal charges now ruling for stores and wages, were detrimentally affected by some 61,392 tons of unpayable development rock being hoisted separately and dumped, the costs in connection therewith being included as a charge against the tonnage milled. Costs were further considerably influenced by the large amount of excess development accomplished during the year. The development footage totalled 18,506 ft., of which 12,658 ft. were on reef, averaging 16·14 dwt. over 20·17 in. The payable ore reserve at the end of the year was estimated at 2,567,000 tons of an average assay-value of 9·8 dwt. per ton over an average stoping width of 58 in. This is an increase of 783,000 tons over the previous estimate, the average assay-value of the total being practically the same as that of a year ago, and the stoping width 2 in. wider. The necessary gear is being collected for sinking No. 3 shaft situated on the new area recently acquired under lease. A seven-compartment rectangular shaft has been decided upon. The extension to the reduction plant, increasing the capacity from 30,000 to 40,000 tons monthly, was put in hand during August, and at the end of the year construction work was well advanced. The slimes plant was completed at the end of January which will allow of a partial increase in the rate of tonnage production. It is anticipated that the increased plant will be in full commission by about the middle of March.

DAGGAFONTEIN MINES, LIMITED.

(Incorporated in the Transvaal.)

Directors : F. R. Lynch *(Chairman)*, H. C. Boyd, H. G, Latilla, E. Oppenheimer, W. Pott, E. A. Wallers. *London Committee :* W. L. Castleden, B. Kitzinger, Sir H. Ross Skinner. *Secretaries :* The Consolida:ed Mines Selection Co., Ltd. *London Secretaries :* Henderson's Transvaal Estates Ltd. *Consulting Engineer :* C. E. Knecht. *Manager at Mine :* H. W. Pridgeon. *Head Office :* The Corner House, Johannesburg. *London Office :* EgyptHouse, New Broad Street, E.C. *Formed* 1915. *Registered Capital :* £730,000 in 730,000 shares of £1 each, of which 81,967 are in reserve.

EXTRACTS FROM THE THIRD REPORT FOR THE YEAR ENDED DECEMBER 31, 1917.

During the year the registered capital of the company was increased from £530,000 to £730,000. Under the flotation agreements the Consolidated Mines Selection Company, Ltd., undertook when called upon, within a period of two years from March 28, 1916, to provide £200,000 further working capital against the issue at par of 200,000 shares. During the year 150,000 of these shares were called up. The capital of the company, at December 31, 1917, was as follows : issued capital, in shares of £1 each, 648,033 shares, held in reserve 81,967 shares.

The flotation agreements covered the following options granted, calculated from March 28, 1916 : To the Daggafontein Gold Mining Company, Limited, for three years at par on 134,126 shares ; to the Consolidated Mines Selection Company, Limited, for three years at par on 115 874 shares, for four years at 22s. 6d. on 125,000 shares, for five years at 25s. on 125,000 shares, total 365,874 ; total number of shares under option 500,000. The property of the company remains as follows : freehold portion of the Farm Daggafontein No. 25, situated in the mining district of Boksburg, Transvaal, in extent 4,363 morgen 326 square roods. On proclamation of the farm, the company, as freehold owners, will become entitled to some 1,257 gold claims ; discoverer's claims, numbered 1 to 179, situated on the Farm Daggafontein No. 25, held under Discoverer's Certificate No. 236.

The cash receipts and expenditure from the inception of your company to December 31 were as follows :

RECEIPTS.

	£	s.	d.
Working Capital—250,000 Shares at 20s. each ...	£250,000	0	0
Cash and Cash Assets taken over from Vendors	2,437	15	4
Interest Received and Sundry Revenue... ...	2 446	0	0
Sale of Surplus Water	688	13	0
	£255,572	8	4

EXPENDITURE.

	£	s.	d.
Transfer Duty, etc.	£8,443	10	4
Shaft Sinking, Permanent Haulage Ways and Equipment...	180,792	11	0
Development	15,511	6	0
General Expenses	14,255	9	1
Balance, being Cash and Cash Assets after deducting Sundry Creditors and Credit Balances	36,569	11	11
	£255,572	8	4

CONSULTING ENGINEER'S REPORT.

Development work at No. 1 shaft was proceeded with during the year, a total footage of 2,633 ft. being accomplished. The footage sampled amounted to 1,620 ft. Of the above footage sampled 62·3% showed payable assays, averaging 22·59 dwt. over 26·37 in. It was decided early in the year to temporarily stop the development headings to the east of the shaft and all work was confined to the West Haulage and 2nd Levels North and South, where very encouraging sampling results have been met with. During September a flow of water was encountered in the 2nd Level South, and, after strenuous unsuccessful attempts had been made to regain the faces by baling, it was decided to instal a pumping plant in the Vertical Shaft at the 2,000 ft. station. This work is now proceeding, and should be in operation by the end of March. No. 2 Shaft was sunk a further 341 ft. during the year and timbered 342 ft. making the total depth at the end of the year 519 ft., of which 502 ft. are timbered. A considerable quantity of water was met with in sinking, and a further amount was proved by means of a bore-hole. At the present time sinking has been temporarily suspended, this being necessary in connection with the adoption of the cementation process, which was decided upon to endeavour to seal the water fissures located by the bore-hole. A pumping station is being cut at 500 ft.

MANAGER'S REPORT.

FOR THE YEAR ENDED DECEMBER 31, 1917.

The total footage during 1917 amounted to 2,633 feet, of which 1,620 feet were sampled, averaging 19·54 dwt, over 21·03 inches.

The following tabulation gives details for the year, together with a summary of the total work so far accomplished :

	Total Footage	Footage on Reef	Footage Sampled	Reef Width Ins.	Assay Value Dwt.
North Haulage ...	249	205	165	11·42	21·42
South Haulage	388	147	150	5·77	15·93
West Haulage	1,232	897	885	14·21	28·47
2nd Level North ...	216	216	185	56·51	12·01
2nd Level South ...	303	265	235	35·26	15·42
Station and Station Roadways	224	—	—	—	—
Crosscuts	21	—	—	—	—
For Year	2.633	1,730	1,620	21·03	19·54
Previously reported ...	2,402	1,690	1,660	6·51	30·87
Totals and Averages ...	5,035	3,420	3,280	13·68	22·26

Owing to an inflow of water in the 2nd Level South on September 21 all development was stopped, and the water in the Vertical Shaft at the end of the year was 10 feet above the roof of the Station.

Water pumped from the 100 ft. Station ...	33,409,000 galls.
Water pumped from the 800 ft. Station ...	33,026,000 galls.
Water baled	122,805,000 galls.
	189,240,000 galls.

The quantity of water supplied to the Rand Water Board during the year amounted to 32,439,000 gallons.

This shaft was sunk a further 341 feet and timbered 342 feet, making the total depth at the end of the year 519 feet, of which 502 feet are timbered. Diamond drilling in connection with the cementation process is proceeding.

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EDITORIAL

NAMES of mines often give trouble even to the initiated. A daily paper, in writing of the East Rand Proprietary's position, referred to the search for ore on the 3,000 ft. level in the "blue sky." The journalist, in interpreting the cable message, failed to grasp the necessity for capitals, but protected himself by using quotation marks, no doubt supposing that the words constituted a technical expression similar to the "blue-water" school.

TECHNICAL periodicals are in demand for the use of the wounded at American hospitals in England, France, and other European countries. If those of our readers who do not file the papers to which they subscribe will send them to the American Red Cross at 154, New Bond Street, London, W., they will thereby perform a graceful service to their friends from across the ocean.

IN this issue we give the first instalment of an article on modern air-compressors. The writer, Mr. David Penman, is already favourably known to our readers as the author of "Compressed Air Practice," one of Griffin's series of books. Another article in this issue to which attention may be called deals with the cascade system of flotation. This article appears in the Mining Digest and is taken from the *Mining and Scientific Press*, our San Francisco contemporary, which is always to the front in matters relating to flotation.

THE Institution of Mining and Metallurgy has published the results of further researches conducted by the Tin and Tungsten Committee. One of the papers describes the investigations undertaken at the Giew concentrator to obtain definite figures for the percentage of recovery. The figure obtained was 65%, which corresponds fairly closely with the conclusions at which investigators have usually arrived when treating this class of tin ore. The percentage is much the same as that associated with the water-concentration of disseminated coppers. As we have remarked on more than one occasion, the desired increase in recovery will not come from improvements in water-concentration, but by the introduction of new methods of extraction. In a second paper Professor S. J. Truscott gives the results of grading analyses of Giew products by elutriation. The other two papers are by Mr. H. W. Hutchin, and deal respectively with investigations of the comparative suitability of various assay methods as applied to low-grade tin ores and products, and with an inquiry into the application of cinchonine in the assay of tungsten ores and products.

LAST October we reported that Judge Bourquin, of the Montana court, held that the Butte & Superior company infringed Minerals Separation patent even if more than one per cent. of oil were used, for the records at the concentration plant proved that worse results were obtained and at a greater cost by adding oil merely with the idea of evading the patent. Butte & Superior entered an appeal in the San Francisco court, and the arguments were heard once more in March. A judgment has been delivered, which appears to have mystified both parties. Until the time we go to press only brief cable messages have been received on this side, and these are difficult to interpret without the context.

TOWARD the end of last year many strange stories were current in the United States daily press, telling how an American engineer had brought home two million dollars worth of platinum from Siberia just before the Russian collapse, the platinum "chained to his wrist." This condition of transport is reminiscent of *Punch's* cartoon showing President Kruger leaving the back-door of the Transvaal for Delagoa Bay mounted on horseback with £2,000,000 in gold strapped behind him. At a recent meeting of the Mining and Metallurgical Society of America the engineer in question, Mr. F. W. Draper, until recently manager of the Verk Issetzk copper mines in the Urals, gave an account of his adventures. He told how the platinum was bought from all sort of sources in face of German competition, by Mr. Norman H. Stines, of the Sissert Company, being financed by a banking corporation in Petrograd. The total amount thus collected weighed 1,965 pounds and was valued at $2,100,000. Attempts were made to induce the American Express Company to effect delivery to the United States, but in vain. Mr. Draper was therefore deputed to undertake the transport. The platinum was made up into parcels weighing about 200 lb. each, which were sealed at the American Embassy. After much thrilling anxiety by land and sea, but without any untoward incident, he fulfilled his commission with complete success, and America was thus the richer in supplies of this necessary metal owing to the sagacity and foresight of her mining engineers in Siberia.

THE Associated Chambers of Commerce have combined with the Institute of Bankers in urging the Government to adopt decimal coinage for this country, and Lord Southwark (formerly Mr. R. K. Causton) has already introduced a bill into Parliament. As we mentioned in our issue of July of last year, the proposal is to divide the sovereign into 1,000 mils, each approximately equal to a farthing. The silver coins would be the florin, quarter florin, half florin, and double florin of 100, 25, 50, and 500 mils respectively; and there would be 5 and 10 mil pieces in nickel, and 1, 2, 3, 4 mil pieces in bronze. While agreeing with this plan for simplifying our coinage, we doubt the necessity for having such a great variety of small pieces. It will be seen, from the support given by the Chambers of Commerce to the recommendations of the Institute of Bankers, that the decimalization of our coinage is agreeable to the trading community. As regards the introduction of the metric system of weights and measures in this country, we regret to see that the Government Committee on trade relations after the war has not seen its way to recommend this step. On the other hand, the cause has received a strong help forward in America, for the authorities there are using both metric and English measures in their instructions to soldiers and others proceeding to France.

ONE of the most interesting of the Memoirs of the Geological Survey of the Union of South Africa is that dealing with the Barberton mining district, written by Mr. A. L. Hall, and it completes a trio of volumes by this author describing the Transvaal goldfields that were discovered before the Rand, the other two being devoted to the Murchison and Pilgrim's Rest districts. The desire to be up to date often leads the mining engineer to forget the early history of mining and metallurgy, and it is therefore well to receive a publication that takes us into the past. Records show that the Murchison gold deposits were the first discovered in the Transvaal, in 1868, and that the year 1873 saw the first workings in the Pilgrim's Rest district. The De Kaap alluvial deposits in the eastern Transvaal attracted attention in 1879, while the deposits near the present town of Barberton were discovered in 1883. Some confusion has arisen owing to the duplication of the name "De Kaap." The name of the alluvial deposits discovered in 1879 was derived from a spur of the Drakensberg range, but the alluvial diggings near Barberton were called after the De Kaap river. The Barberton district became famous by the discovery of the Sheba mine in 1886. Barberton was founded in the same year by Graham Barber, a pioneer from Natal. For some time we heard much in London of properties in the De Kaap valley, especially Moodies, and also of gold mines at Komati over the border of Swaziland. The Sheba, after varying fortunes, is now closed, only temporarily we hope. The Pigg's Peak mine in Swaziland is also another old stager, and there is a chance that its life will be prolonged by the mining of ore for its sulphur content. Mr. Hall's monograph revives old memories, and serves also to demonstrate the difficulties with which all these mines have had to contend. His geological reports indicate other possibilities for exploration and development when labour once more becomes available.

Improvements in Zinc Metallurgy.

In this issue we publish a short but highly important article by Mr. Gilbert Rigg, describing a new method of roasting zinc concentrate introduced at the Port Pirie smelting plant belonging to the Broken Hill Associated Smelters Proprietary, Limited. Parenthetically we may remark that the author is a metallurgical and chemical engineer who gained his early experience in the North of England, subsequently going to America and joining the staff of the New Jersey Zinc Company. A year or two ago, when the Broken Hill smelting business passed to the new control, he went from America to Port Pirie to study the local problems and review the metallurgical practice. One of the researches related to the roasting of zinc concentrate and the production of material that would give better results in the distilling retorts. As is well known, it is easy to remove three-quarters of the sulphur contained in zinc concentrate by roasting in a reverberatory or muffle furnace, but it takes much time and fuel to reduce the sulphur content from 8 to 1%, owing to the difficulty of bringing the air into contact with the sulphide particles. In fact the activities of the inventors of roasting furnaces have been devoted almost entirely to the problem of effecting this contact by improved methods of rabbling and in other ways. At Port Pirie it was decided to let the reverberatory or muffle roasters do their work to the limit of efficiency, that is to say to roast down to 8 or 10% of sulphur, and then to transfer the material to a Dwight-Lloyd sintering machine. The results were immediately successful, for it was found that one passage through the sintering furnace effected a reduction of the sulphur to 1½% or less, the operation occupying minutes instead of hours, and no fuel being required beyond that used for the initial ignition. The benefits accruing consist of a halving of the coal bill and the doubling of the capacity of the plant. This is not all, however, for the sinter produced is a much better material for the distilling retorts than the finely divided roasted concentrate. The sinter partakes of the physical nature of calcined carbonate in that it permits of the circulation of zinc vapour and reducing gases within and through it. Thus the retort charge requires a smaller proportion of coal, an advantage which not only reduces the cost of fuel but permits of an increased amount of zinc-bearing material entering each retort charge. At Port Pirie it has been found that the retort capacity is increased by 15% in this way. Like all new inventions, the sintering of zinc concentrate presented some troublesome obstacles at the start. The most prominent of these were the losses by dusting and the failure of the charge to ignite. At first, as much as 10% of the charge was lost as dust owing either to the upward draught carrying the fine particles with it, or to the formation of blow-holes which allowed some of the material to drop into the windbox. Eventually the partly roasted ore was damped by water and fine slime-concentrate before being placed in the sintering moulds, a process that largely prevented the formation of blow-holes and substantially reduced the losses in dust. The difficulty of securing ignition was traced to the fact that after the preliminary roast the remaining sulphur is in the kernel of the grains which are coated with oxide. The addition of about 10% of unroasted concentrate was found to supply the requisite amount of sulphur for securing efficient ignition. With these two improvements the new roasting process has given highly satisfactory results. It may be asked why the concentrate is not sent direct to the Dwight-Lloyd plant, instead of being given the preliminary roast in the ordinary furnace. The answer to this is that a charge of unroasted concentrate melts and has to be continually cooled, re-crushed, and re-treated.

In looking through recent technical literature we have found that an American pioneer in the application of the electric furnace to zinc reduction, Mr. Woolsey McA. Johnson, has been engaged in researches for the object of securing better contact between the reagents in the distilling operation and at the same time providing openings for the more rapid exit of the zinc vapour and gases, or as he says obtaining better "ventilation." For the benefit of readers we quote from his paper in the Mining Digest. He secures his results by grinding the roasted concentrate and the fuel to a greater degree of fineness, and adding to the mixture, which is formed into briquettes, a certain amount of broom straw which provides ducts for the escape of the gases. He has found that by this method he can reduce the amount of coal added to the charge and bring it more nearly to the theoretical amount required. He thus obtains a retort material that is more amenable to treatment by means of artificially introduced ducts, whereas at Port Pirie the same "ventilation" is provided by the sintery condition of the roasted material. The Port Pirie process has, however, the additional advantage of greatly simplifying the roast.

Wolfram in Depth.

On another page we quote from a lecture recently delivered by Dr. W. R. Jones on the origin of the wolfram found in Burma and the prospects for the continuance of the deposits in depth. Dr. Jones is one of our younger economic geologists, who has already done great service to mining by dispelling the chaos of contradictions which until recently served as theories for the origin and occurrence of cassiterite and wolfram in Malaya, and by evolving a logical and acceptable explanation on which to base recommendations for exploration and development. We have had the pleasure of publishing two contributions from his pen, and hope to present another within a short time. Our object in writing this short note is to draw attention to his theory as to the carriers of wolfram and tin. He says that while in Malaya the fluorine-bearing minerals such as tourmaline, topaz, and fluorspar are abundantly in association with wolfram and cassiterite, and that there is therefore no difficulty in assigning to the fluorides the role of carrier, the evidence in the Tavoy district in Burma points to the sulphides as having acted as carrier. In Malaya tourmaline is plentiful, and the Chinese coolies speak of it as the friend of tin. In the Tavoy district, on the other hand, fluorine minerals are very scarce, and the persistent searches of Mr. J. Coggin Brown, the Government geologist for Burma, have failed to yield many specimens. Between these two centres there is the Mergui district, where both fluorides and sulphides are associated with the wolfram and tin. Dr. Jones is at present preparing a paper examining in detail the association of the wolfram and tin at Tavoy with sulphides, and demonstrating his theory scientifically. We look forward with great interest to this forthcoming paper. Until it is published any discussion of the theory is inopportune. It is advisable, however, to review briefly, for the benefit of lay readers, Dr. Jones's views of the geology of Malaya and Burma; and perhaps also some technical readers may find the reference acceptable, particularly on one point which was tucked away in a contribution to a discussion on another paper presented to the Institution of Mining and Metallurgy. Dr. Jones first of all combated the old theory that most of the tin in Malaya is found in alluvium deposited in the Glacial period, having been brought down from some unknown ultimate source. He then demonstrated that some deposits which had been taken to be a sort of clastic rock, that is to say, a cemented alluvium, were in fact real veins, though highly weathered and decomposed. With these two bogies out of the way, Malayan geology was found to conform to the usual rules, and it became possible to show that the tin and wolfram are constituents of lodes and veins associated with the great granite upheaval and intrusion extending from the Southern Shan States in Burma, through the Tavoy and Mergui districts, right through the Malay Peninsula to the islands of Banca and Billiton. The second or more acid phase of this intrusion occurred after the first and more basic intrusive had become partly consolidated and fissured. In this second phase came the wolfram and tin, which are found in lodes and veins penetrating both the granite and the adjacent schists and phyllites. Dr. Jones collected evidence, agreeing with the views and experience of Dr. Malcolm Maclaren, showing that wolfram and cassiterite were deposited from the solutions at comparatively low temperatures, and that wolfram was deposited at a lower temperature than the tin. Thus, as a general rule, wolfram is found at a higher horizon that the tin. These facts led Dr. Jones to the theory, referred to in the foregoing as being hidden away in a discussion, that the southern part of the tract of country has been denuded to a much greater extent than the northern part, and that the parts representative of the Tavoy deposits have long since disappeared from Malaya. The deduction from this theory is that in depth the Tavoy mines will come to tin on the horizon corresponding to the Malayan formation the disintegration of which has provided the most ancient parts of the tin-bearing alluvium. The presence of wolfram in the tin-bearing alluvium in Malaya is well known nowadays, for the sections of ground previously considered troublesome have been worked to profit since the demand for wolfram arose and magnetic separators were provided locally and in this country. It is to the credit of Mr. Henry Brelick, of the firm of Pawle & Brelick, who wrote on the subject in our pages two and a half years ago, that attention was drawn in this country to the existence of extensive supplies of alluvial wolfram on the eastern side of the Malay Peninsula. On the islands of Banca and Billiton, wolfram is found with the tin in the gravels, and also in the lodes. The general conclusion from all these considerations is that the Tavoy wolfram lodes will continue to a much greater depth than was expected by the pioneers and that the proportion of tin present will substantially increase. The theory of Dr. Jones relating to the carriers of wolfram should still further elucidate this point. We are aware that there are geologists who do not agree with Dr. Jones's conclusions with regard to the persistence of Tavoy wolfram deposits in depth, but these discussions are beneficial to the advance of geological science.

The Formation of Diamond.

As briefly recorded last month, Sir Charles A. Parsons, of steam-turbine fame, lectured before the Institute of Metals early in May, recounting his experiments on the formation of the diamond and advancing a theory to explain the reactions under which he had succeeded in producing transparent crystals. It has hitherto been the theory, as propounded by Moissan and Crooks, that molten iron acts as a solvent of graphite under enormous pressure and heat, and that the carbon crystallizes out of this solution as diamond on the lowering of the temperature under suitable physical conditions. These conditions were not understood, and they were considered of less importance than the initial pressure and temperature. Moissan, in 1892, did in fact produce minute crystals in this way. Sir Charles Parsons undertook a series of experiments in the years 1886-7-8, and read a paper before the Royal Society in the last named year. He resumed the research in 1907, reading another paper subsequently, using a hydraulic press giving pressures of 2,000 tons per square inch, and heated with an electric current measuring as much as 80,000 amperes at 48 volts. Under these conditions the first experiments were with various carbon compounds in the absence of iron. The reduction of these compounds was always found to result in the production of graphite. It is true that occasionally microscopic crystals were found, but the formation of these was apparently due to the accidental presence of iron introduced either in the charge itself or by the melting of some part of the apparatus. The next series of experiments had for their object the melting of carbon itself. When using the press for this purpose it was found that the only effect was to slightly modify the physical condition of the graphite. Another apparatus was therefore devised, somewhat in the nature of a gun. By this means it was possible to rapidly compress the hottest possible flame, that of acetylene and oxygen, with a slight excess of the former to provide the carbon. In this way an exceedingly high pressure, over 15,000 atmospheres, and a temperature of from 15,000 to 17,700°C were obtained for a short space of time, and momentarily a pressure twenty times as great. Here again the results were negative. Other similar guns were afterward used, obtaining probably even higher temperatures and pressures, and using other substances in the reaction, but in no case could anything but amorphous carbon be obtained.

Sir Charles Parsons then proceeded in his lecture to describe experiments and arguments showing that occluded gases in molten iron, and not simple pressure and heat, are the active agents in producing diamonds. He showed that if, in cooling, cracks are allowed to form in the solidified crust, no diamonds are produced, but that if the skin of the ingot or spherule is so carefully cooled as to be gas-tight all round, diamonds are formed. One of the experiments in this connection was of considerable interest. It consisted of effecting the heating of the charge by electric current under a vacuum, and the result showed that no diamonds were formed in the charge when all the occluded gases were removed, but that they crystallized out of such portions of the charge as were ejected by the escaping gases. Furthermore, under a low vacuum, averaging 1 in. of mercury, and with carbon monoxide in the container, the slow cooling of the charge induced the formation of crystals up to 0·7 millimetre in length. In considering the action within the ingot, it has to be remembered firstly that a solidified shell of highly carburized iron is not strong enough to withstand a greater pressure than 1,000 atmospheres. When it cools below 600°C it becomes impervious to gases. As the coat thickens, the gases are ejected from the solidifying metal and are forced inward. Thus gradually the gases accumulate near the centre at an increasing pressure. It is known that natural diamonds contain cavities containing gases under high pressure, a fact confirming the above deductions. The diamonds may be supposed therefore to be formed after the metal is set. This supposition is confirmed by the fact that a diamond is rapidly corroded by highly carburized iron just before setting. Sir Charles Parsons, after fully considering the circumstances here outlined, considers that the diamond is formed at a temperature of about 690°C, one of the points of recalescence, while the metal is still somewhat pervious to gases. To secure the right conditions for the formation of diamond, it is probably necessary to give a heat treatment at high temperatures and to produce carbides within the mass other than those of iron, which react with the occluded gases after solidification. The view that carbon monoxide is the most important of the occluded gases is supported by the increased yield of diamond from iron that has absorbed much of this gas before cooling, and also by the fact of its combination with the metals and with silica and sulphur as carbonyls. Its action in association with iron on carborundum appears to further emphasize this view. There is strong evidence for believing that the action may take place solely between iron, carborundum, sulphur, and carbon monoxide, but as the yield of diamond is always extremely small, very minute traces of some of the elements may be sufficient to satisfy the action, and such elements may as yet have been overlooked. It will be seen that these speculations offer an extensive and fruitful field for investigation. To sum up Sir Charles Parsons' conclusions, we may say that mere heat and pressure within the range of our possibilities do not produce a crystallization of carbon, but that the diamond is formed during cooling of the iron at comparatively low temperatures in the presence of occluded gases. We invite some of our geologists to apply this theory to the explanation of the formation of diamonds in kimberlite.

REVIEW OF MINING

Introductory. — The latest thrust by the German army, carrying their line to forty miles from Paris, has been the predominant feature of the past month. In the mining market, the issue of the reports for 1917 by the South African companies has almost monopolized the attention of investors. In the metal market, the price of silver has been made stable by the action of the American Government recorded last month. The Government control of the tin market, and the more complaisant attitude of the Dutch Government as regards the export of tin from the East Indies, have had a wholesome effect in reducing the price of tin, and bringing it toward a more reasonable range.

Transvaal.—There appears to be a good deal of industrial and political unrest on the Rand at present. Strikes among the electricians have occurred, and local associations of shareholders have been restive against the boards of some of the mining companies. For instance, adverse criticism has been launched, with no good reason, against the Springs deal with the Anglo-American Corporation. Another episode was the wrangle at the meeting of shareholders in the Witwatersrand Deep. This company was taken over by the Central Mining with the other Neumann assets, and the mine has been doing badly lately. Two of the Central Mining directors have withdrawn from the board in favour of nominees of the dissentients, but the opposition party will not be benefited in the result.

The meeting of the Consolidated Mines Selection Company, held in London on May 23, was marred by the presence of a professional agitator, who had previously by circular attacked the board for not getting rid of enemy holdings. Mr. Walter McDermott, the chairman, replied by saying that these holdings were under the control of the Public Trustee and the Board of Trade, and a shareholder said he had himself offered to buy the whole of these holdings but the Government authorities had declined to sell. These statements knocked the bottom out of the agitator's case, but he still attempted to argue the matter, and was only induced finally to withdraw his amendment by the obviously hostile attitude of the other shareholders present. As regards the legitimate business of the meeting, Mr. McDermott announced that the company formed by the Anglo-American Corporation to work the Rietfontein West is to be called West Springs, Limited, and that the Consolidated Mines Selection will have the technical management of the new company. He also mentioned that the main incline in Springs had already been driven several hundred feet into the Rietfontein East property recently acquired, and that the reef continued to be valuable as regards both width and content. In his reply to a vote of thanks, he introduced characteristic touches by saying he did not intend to be "under the heel" of "the hidden hand," and that the success of a mining company depended not only on good management but good luck.

We regret to record that circumstances are against the East Rand Proprietary Mines, and that the end of operations is in sight. The quarterly statement of account to March 31 shows 366,800 tons milled for a yield of gold worth £425,842, or 23s. 3d. per ton, and a working cost of £410,555 or 22s. 5d., leaving a working profit of only £15,287. Other expenditure, including redemption of debentures, resulted in an adverse balance of £8,962. As it is necessary to provide £33,000 per quarter for standing charges such as debenture interest, debenture redemption, phthisis compensation, government taxes, and undermining rights annuity, it is obvious that the company is insolvent. The developments continue to be disappointing, and there is no indication of any possibility of improvement. The directors have found it necessary therefore to suspend development, and to continue milling only as long as the tenour of the available reserve warrants. At the same time as this announcement was made, the report for 1917 was issued. This shows that 1,741,300 tons of ore was milled, yielding £1,910,383, or 21s. 11d. per ton, against a working cost of £1,721,432, or 19s. 9d., leaving a working profit of £188,951, or 2s. 2d. per ton. This profit was, however, more than demolished by debenture redemption £114,150, expenditure on capital account £76,360, and taxes, etc., £20,149. The ore reserve on December 31 was estimated at 2,732,000 tons, averaging 6·2 dwt. per ton. The East Rand Proprietary will be greatly missed, as it has been a great gold producer. Since the amalgamation of the several mines in 1908, the yield of gold has been worth £24,647,835, extracted from 18,120,496 tons of ore, while £5,030,957 has been distributed as dividends.

It is not so long ago since we used to write an editorial every year comparing the performances of the three great consolidations on the Rand, the Crown Mines, East Rand Proprietary, and the Randfontein Central. Those were the pleasant cheerful days when performances and prospects were equally satisfactory. In the preceding paragraph we have chronicled the coming end of the East Rand Proprietary. The Crown Mines is now paying a much smaller dividend than it did at first, and the reserves have shrunk; while the Randfontein Central is going through a period of drastic reorganization.

The output at Crown Mines during 1917 was £2,700,095 from 2,100,000 tons of ore milled, this being a yield of 25s. 9d. per ton. The working cost was £2,026,129, or 19s. 4d. per ton, leaving a working profit of £673,965, or 6s. 5d. per ton. The dividends absorbed £376,042, or 40%, comparing with 120% the year after the big consolidation. The ore reserve at December 31 last was estimated at 8,988,000 tons averaging 6·3 dwt. The ore developed during the year was 1,366,000 tons averaging 7·5 dwt. per ton. About 1,000,000 tons previously developed had to be removed from the estimate as it is of too low a grade to pay at the present level of costs.

At the Randfontein Central 2,017,195 tons of ore was milled during 1917 for a yield of £2,497,635, being 24s. 6d. per ton. The working cost was £2,007,938, and in addition £205,391 was spent on capital account, £213,223 was paid as debenture interest, and £97,100 in redemption of debentures. Since the control was acquired by the Johannesburg Consolidated, it has been found necessary to sink two new vertical shafts to 5,000 ft., and until these are completed the mine cannot be worked to the best advantage. The development has been promising lately, and the reserve has been increased, now standing at 5,185,000 tons averaging 6·8 dwt. per ton.

The New Kleinfontein presents another example of the necessity for writing down the ore reserves by eliminating blocks not profitable to work at the present level of costs. In this case 680,000 tons has thus been written off, bringing the figures to 2,214,000 tons averaging 5·64 dwt. per ton. The current developments are not at all satisfactory, for during the first quarter of this year only 20% of the newly developed ground sampled is profitable. The development of the old Kleinfontein section will be completed in 1920, and after that greater attention will have to be paid to the Apex section.

Rhodesia. — The output of gold during April is reported at £239,916, as compared with £230,023 in March, and £296,977 in April of last year. The Cam & Motor gave a rather better return for April. The Eileen Alannah has closed down, owing to an accident to the power plant and to the rise in costs. Of other production in Southern Rhodesia during April may be noted 41,093 tons of coal, 312 tons of copper, 917 tons of chrome ore, and 570 tons of asbestos.

At the Rhodesia Broken Hill, prospecting by bore-hole is giving good results and the information acquired indicates that the orebodies are big and continuous, warranting an expansion of operations.

West Africa.—The output of gold during April was valued at £117,520, as compared with £112,603 in March, and £123,825 in in April, 1917. Prestea Block A and Abbontiakoon show rather better figures for the month. In an American contemporary the fall of the West African output for 1917 was attributed in part to the decadence of Ashanti Goldfields; this was a mistake, for, as our readers are aware, the property is still quite healthy.

Nigeria.—The accounts of the Mongu tin mining company for 1917 introduce for the first time returns from the dredge. This dredge was put in commission in the middle of July, 1917, and from then onward to the end of 1917 extracted 104 tons of tin concentrate. By sluicing and calabashing 467 tons was produced, bringing the total output to 571 tons. The net profit was £42,222, and it is estimated that of this £17,000 will be due as income tax and excess profits duty. The shareholders receive £21,012, being at the rate of 22½%, less income tax.

The Bisichi report for 1917 shows an output of 278 tons and a profit of £25,250, of which £25,000 has been distributed as dividend, being at the rate of 12½%.

The Kaduna is a company that has always kept its capital low. The most recent example of its excellent methods of finance is the conversion of debentures into shares. The share capital is only £13,885, and the cash reserve stands at a similar amount. During the last completed twelve months, the shipments of tin concentrate totalled 256 tons, and the profit was £12,973, out of which £6,942 was distributed as dividend, at the rate of 50%.

Congo State. — In our issue of May last year, we gave an account, with a map, of the rail and water communications in the Belgian Congo. It was then mentioned that the railway between Bukama on the Upper Congo river and Kambove in Katanga was under construction. News is now to hand that this railway is completed, and thus through connection is made between Cape Town and Bulawayo with the Congo. Transport by rail and water is already in operation between Bukama and Boma at the mouth of the Congo. The opening of the Kambove-Bukama line marks an important epoch in African continental communications.

Australia.—The Broken Hill Proprietary is about to rearrange its capital in order to capitalize profits and to provide further funds for the expansion of its steel business. To begin with, the 318,994 unissued 8s. shares are to be offered to shareholders at £2 each, in the proportion of one share for every four now held of the 1,181,006 shares hitherto issued. The whole of the authorized capital, 1,500,000 shares of 8s. each, will then have been issued. The board will then create 1,500,000 new shares of 12s. each and distribute them among shareholders as a bonus, this operation constituting the capitalization of £900,000 reserve fund built up out of accumulated profits. These two series of 1,500,000 shares will then be amalgamated into a similar number of shares of £1 nominal value. After the consolidation has been effected, a further 600,000 shares of £1 each will be distributed as a bonus, at the rate of 1 share of £1 each for every 2½ held of the 1,500,000 £1 shares, this distribution also constituting a capitalization of undistributed profits. In addition, 900,000 new shares of £1 each will be created, to be issued at some future time whenever required. By this alteration of capital, each holder of 10 old shares will pay £4 and obtain 14 shares of £1 each.

The mining of molybdenite continues to attract attention in New South Wales. The Yetholme Development & Mining Co. has been formed in Sydney to acquire the Lithgow property on the slopes of Mount Tennyson. The available ore is estimated at 3,000,000 tons, and a trial shipment gave an average content of 1·7% MoS_2. The Mammoth Molybdenite Co. has been developing an adjoining property for over a year, and the crushing and concentration plant started in March. A new wolfram district at Yanco Glen and Thompson's Siding, 20 miles from Broken Hill, is attracting attention, and a number of workers financed from Adelaide and Melbourne are conducting prospecting and development operations.

Cock's Pioneer, the alluvial mine in New South Wales which produces both tin and gold, and which was described by Mr. A. H. P. Moline in our issue of July last year, gave an output of 4,064 oz. of gold and 61·3 tons of tin concentrate from 364,000 cu. yd. of ground during the six months ended November 30 last. The net profit was £12,017. Recent operations have shown that the area of profitable ground is greater than previously supposed, and boring operations are being undertaken to ascertain its extent.

Mount Elliott unfortunately suffers from a succession of labour troubles. It is now reported that all the men went on strike on May 28, without any warning, owing to the refusal of the manager to reinstate an engine-driver who had been discharged for gross carelessness.

Malaya.—At the annual meeting of the Chamber of Commerce of the Federated Malay States, Mr. F. S. Physick, the chairman, gave a review of the trade of the states during 1917. During the year the export of tin amounted to 39,833 tons, a decline of 4,037 tons on the previous year's export figures, but prices ruled higher and new records were established. On the other hand, a satisfactory increase in the export of tungsten ores was recorded. There was produced and exported 319 tons of wolfram concentrate. This shows only a small increase over 1916, but it is over 50% greater than the exports of 1913. In addition, there was 245 tons of wolfram re-exported, which was won by separation of imported mixed ores. The production of scheelite was 396 tons, being double that of 1916. With a total output of tungsten concentrate of 715 tons for the year, an increase of about 200 tons was made over 1916.

Cornwall.—The scheme for consolidating the ordinary and priority shares in Tincroft Mines, Ltd., outlined last month, has been abandoned owing to unexpected opposition from some London shareholders. We believe these opponents constituted only a small minority. Local shareholders wonder that some modified scheme could not be evolved that would please all parties.

Canada. — As recorded in our March issue the British America Nickel Corporation abandoned the project of erecting a refinery in the Sudbury district, owing to the difficulty of securing cheap electric current. Since then it has been decided to erect the plant at Deschênes, Quebec. Our Toronto correspondent sends us information relating to the future policy of the other Sudbury nickel producer, the International Nickel Co., of New York.

United States. — Herewith are given the main figures showing the results at the Hayden-Stone-Jackling group of porphyry copper mines. The outputs are in short tons, and the operating costs do not include the taxes. The only mine at which much development has been done during the year was the Nevada Consolidated, where the reserve is now calculated at 70 million tons.

RESULTS AT UTAH CONSOLIDATED (UTAH), 1917.

Tons of Ore	12,542,000
Tons of Copper Produced	97,918
Pounds of Copper per Ton	15·61
Operating Costs, Cents per lb.	8·43
Net Profits	$28,695,495

RESULTS AT CHINO COPPER (NEW MEXICO), 1917.

Tons of Ore	3,608,100
Tons of Copper Produced	39,818
Pounds of Copper per Ton	22·07
Operating Costs, Cents per lb.	10·24
Net Profits	$9,512,854

RESULTS AT RAY CONSOLIDATED (ARIZONA), 1917.

Tons of Ore	3,560,900
Tons of Copper Produced	44,291
Pounds of Copper per Ton	24·87
Operating Costs, Cents per lb.	11·03
Net Profits	$9,701,169

RESULTS AT NEVADA CONSOLIDATED (NEVADA), 1917.

Tons of Ore	4,064,095
Tons of Copper Produced	41,020
Pounds of Copper per Ton	20·18
Operating Costs, Cents per lb.	10·79
Net Profits	$9,408,892

In October last we mentioned that the American Smelting & Refining Co. had served a writ on the Bunker Hill & Sullivan for breach of contract. In 1905 the mine had undertaken, on a 25 year contract, to sell its lead ore to the smelter, but a year ago commenced to smelt its own products. It appears that the agreement was so indefinite that a proper interpretation according to present conditions in the Cœur D'Alene lead-mining district was practically impossible. It has therefore been agreed, out of court, to cancel the agreement and substitute a new one, whereby the products are divided equally between the two companies, and leaving both free to compete for other ores from the same district.

The Camp Bird company announces that a lode has been cut in the tunnel, which is presumed to be the continuation of the main lode. It will be remembered that, on the exhaustion of the ore-bodies, the directors decided to explore the ground below by means of a tunnel driven at a lower level. The calculation was that the lode would be cut in this tunnel at a distance of 10,700 ft. from the portal, and at a vertical depth of 1,425 ft. below the bottom workings. The intersection has been actually made at 11,000 ft. The assays of the material composing the lode have not yet been made, but both lode and country are geologically favourable. It is interesting to record that Mr. C. W. Purington indicated that the lode would continue in depth, as long ago as 1902.

Mr. Hennen Jennings has recently issued a pamphlet dealing with the economic side of gold mining, his object being to combat the views expressed in several quarters in the United States that the maintenance of the output of gold is not vitally necessary under present conditions. We have in a previous issue noted this attitude of many American politicians and mining engineers, who consider that the mineral products used directly in warfare should have the first claim for labour, supplies, and transport. Mr. Jennings shows that bankers are as pressing in their demand for gold as the munition makers are for their raw materials.

In April we mentioned that the Tomboy, in Colorado, was hit by scarcity of labour and increased costs. The directors now announce that the monthly profit may be expected to be about $10,000 instead of $30,000, the figure to which shareholders had been accustomed.

Mexico.—The Santa Gertrudis reports, for the quarter ended March 31, an output of £208,703 from 80,769 tons of ore, and a profit at the mine of £68,987. The plant worked at only 83% of its capacity, owing to an increasing proportion of slime being produced, and there being inadequate facilities for settling and filtering. The additional plant required is now being provided. Flotation experiments show that this method cannot compete with cyanidation.

Brazil.—The outlook at the Passagem gold mine, of the Ouro Preto company, is not too bright. No payable ore has been disclosed so far on the 1,040 metre level. The proved reserve is estimated at about nine months supply, though Mr. A. J. Bensusan, the superintendent, has good reason for believing that there is enough ore to keep the mill going for two years. The supply of labour has been short lately owing to the superior attractions of manganese mining operations, and both development and stoping have been restricted. During 1917 the tonnage treated was 82,500, as against 87,600 in 1916. The yield per ton was 27s. 11d., as compared with 27s. 8d., and the working cost was 26s. 5d., as compared with 25s. 7d. After allowing for depreciation and taxes, the profit for the year was only nominal.

NOTES ON A NEW METHOD OF ROASTING ZINC SULPHIDE ORES

By GILBERT RIGG.

THE present paper, as its title implies, is of a preliminary nature. Its object is to give a résumé of work done and results so far achieved, leaving a fuller and more detailed account for a future paper when certain lines of investigation have been more completely followed out. Seeing, however, that several hundred tons of Broken Hill zinc concentrate have been successfully roasted by this new method, and subsequently treated in the distillation furnaces, at the plant of the Broken Hill Associated Smelters Proprietary, Port Pirie, South Australia, it is felt that this method may now be put forward safely as reliable and economical. At the Port Pirie plant the method is now in regular operation on a scale of 30 tons of concentrate per day.

The roasting of zinc sulphide ores down to a percentage of sulphur at which they may be safely used in the zinc retorts (this means a sulphur content of less than 2% in the roasted ore), presents certain features of importance where economy both in fuel and labour is essential. The elimination of from two-thirds to three-fourths of the sulphur requires but little fuel and proceeds rapidly, and with little difficulty in furnaces of the reverberatory or muffle type. The elimination of the remainder, however, consumes both time and fuel out of proportion to the sulphur removed, and calls for a great deal of care and watchfulness, and for somewhat elaborate and costly equipment. The work described in the present paper was directed toward finding a more effective and economical method of dealing with the ore after the sulphur had been roasted off in a reverberatory or muffle furnace to the limit at which this method falls off materially in economy.

It has been found that this problem can be successfully solved by subjecting the partly roasted concentrate to treatment by the blast-roasting methods which have proved so valuable in the roasting of lead sulphide ores. Certain precautions are necessary, which will be described further on, but with no more fuel than is necessary for the preliminary ignition, partly roasted zinc concentrate containing 10% sulphur can be brought down to 1%, and the roasted product gives excellent results when used in the distillation furnaces. The blast-roaster we have used is a Dwight and Lloyd machine of standard design and about two-thirds the size of the machine generally used for roasting lead sulphide ores. This machine happened to be available when the experiments were started, but there is no reason to suppose that a standard size machine would not do equally good if not better work.

The following is a detailed description of the modus operandi.

The pre-roast is at present carried out in a Ropp roaster designed originally for roasting lead concentrate and fired with producer gas. The same furnace has been used for roasting zinc concentrate down to 2% sulphur, on which work its capacity is 15 tons of concentrate per day. Working as a pre-roaster and delivering a product containing 10% sulphur it treats from 30 to 33 tons per day. The daily consumption of coal is a little less than half the amount required when roasting down to 2% sulphur, so that the coal consumption per ton of concentrate is cut down to less than half that required on the dead roast, while the furnace capacity is fully doubled.

The Ropp furnace is by no means an ideal one for pre-roasting. It is wasteful of fuel and was used because it was the only roaster available at the time. A Herreshoff furnace is now being installed for this purpose.

So far our results indicate that a sulphur content of 10% in the pre-roasted ore gives the most economical result in the final roast. It is quite possible, however, that with other ores, and different conditions as to fuel costs, etc., this figure might have to be varied. With our concentrates, a pre-roasted ore at 10% sulphur can be roasted down to 1·5% or less on one pass over the Dwight and Lloyd machine.

It is not within the scope of this paper to give a complete description of the Dwight and Lloyd machine. Moreover it is now such a well known and widely used piece of equipment that such description is hardly necessary. It is only desirable to say that the charge is carried forward on moving grates, the grates passing under an ignition burner, which starts the sulphur in the ore burning, and over a windbox in which a partial vacuum of 8 inches or more of water is maintained. Once the charge has passed from beneath the burner it depends for the maintenance of a roasting temperature on the sulphur in the ore exclusively.

It has been recognized by zinc metallurgists that the difficulty of maintaining good contact between the oxygen of the air and the sulphur of the ore in a reverberatory or muffle furnace in which the bed of ore is thick enough to be economical, is the main cause of the slowness of the final desulphurization, and a great deal of thought and ingenuity has been devoted to the improvement of the stirring mechanism. In the case of the blast-roaster, however, the air is drawn down through the bed of ore and between the particles, thus maintaining what may be called a "rubbing contact" and greatly accelerating the elimination of the sulphur. It is perhaps not surprising, therefore, that what takes hours to perform in the old way takes only minutes on the blast-roaster.

It may perhaps be asked "why not do the whole operation on the blast-roaster"? So far we have not found it possible to keep down the temperature of a bed of green ore on the machine below its melting point. The charge slags badly and needs repeated crushing and re-passing over the machine. A mixture of roasted and green ore works better, but so far as our work has gone it seems best to use the two methods of roasting, each within its most effective range, the reverberatory or muffle for the pre-roast and the blast-roaster for the final roast.

The roasted product is a dry, somewhat crumbling sinter, in which the grains of ore are easily seen. The question of crushing and its relation to the subsequent distillation is discussed further on in this paper.

In developing the blast-roasting method numerous difficulties were encountered at first. The dust loss was excessive, amounting to as much as 10%. Blow-holes in the ore bed were numerous and troublesome and had a great deal to do with the dust loss, the ore running through the grate into the windbox and being carried off by the fan. A cyclone dust-catcher was installed and took care of the loss for the time being. Again the ignition was patchy, considerable sections of the charge failing to ignite properly and coming over imperfectly roasted.

Taking the last trouble first, it is undoubtedly connected with the condition of the sulphur in the charge. The sulphur which has escaped roasting in the pre-roast is to a large extent in the form of kernels of green ore coated with roasted ore, and these do not ignite readily. To remedy this a small amount of green ore was mixed with the pre-roast to serve as an igniter. This worked well and has been adopted in our practice. The stronger and more universal ignition also strengthens the bed and minimizes blow-holes.

A further improvement was made by utilizing green zinc slime-concentrate. The material is so fine that it is colloidal in character and forms a plastic mass with water. By damping the pre-roasted ore with a mixture of water and this slime-concentrate, the ignition was good, the blow-holes disappeared, and the amount carried over and caught in the dust-catcher went down from 10% to 2% or less. When slime was not available, about 2% of plastic clay was used with very good results to hold the charge together on the grates. When green ore is used the amount added is equal to 2% of sulphur on the weight of pre-roasted material sent to the machine. This means that the pre-roasted material must be correspondingly lower in sulphur, but as a corresponding amount of green ore goes direct to the machine without the preliminary expense of pre-roasting, the economic balance remains about the same.

We estimate the capacity of a standard machine with properly designed accessory apparatus to be equal to 90 tons of pre-roasted ore per day carrying 47 to 48% zinc and 8 to 10% sulphur.

The physical character of the feed to the blast-roaster, its moisture and sulphur content, must be maintained as uniform as possible in order to get the best results. In this respect the operation is in accord with blast-roasting work in general. As mentioned above, the roasted product is in the form of cakes of lightly sintered material, in which the original ore-grains are usually easily discernible under a glass. It is very easily crushed, but an interesting feature of the method is that the roasted ore gives perfectly good results in the distillation retorts when charged in much coarser form than is usual with roasted zinc blende. We find that crushing through a round hole three-eighths of an inch in diameter is quite sufficient. It is well known that zinc carbonate ores can be charged into the retorts crushed through half-inch with good results, and in this respect the crushed sinter behaves very much like a carbonate ore. Both are quite porous, admitting free entry of the reducing carbon monoxide gas into the ore grains, and the circulation of this gas through the charge is freer than is possible with finely crushed roasted blende. Moreover less reducing fuel is necessary than in the latter case, and the weight of ore charged per cubic foot is materially increased. In our furnaces the increase amounts to 15 per cent.

As regards the utilization of the sulphur in the ore for the manufacture of sulphuric acid, the SO_2 furnished by the pre-roast will be in the form of a gas probably decidedly richer than can be obtained when roasting sweet in a muffle furnace. As regards the blast-roast more work is necessary before final figures can be given. It would appear at present that by arranging the wind-box so that the richer part of the gas can be taken off separately, a gas containing about 3% of SO_2 can be obtained. Our intention is that, as soon as our Herreshoff roaster is in commission, the gas from the Dwight and Lloyd machine will be sent through it, so that this gas may become enriched by contact with the ore while the latter is still rich in sulphur. We estimate that from 75% to 80% of the sulphur in the ore can be brought into the form of a gas rich enough in SO_2 to be suitable for sulphuric-acid making, but final figures, as stated above, cannot be given as yet.

The following cost estimate is based on a plant consisting of multiple-hearth muffled roasters of the Herreshoff, Wedge, or Skinner types used as pre-roasters and Dwight and Lloyd blast-roasting machines for the final roast.

PRE-ROAST: Capacity per furnace per day equals 30 tons green ore roasted down to 8% sulphur.

Cost per day:	£	s.	d.
Coal, 1·5 tons @ 14s	1	1	0
Labour, 3 men @ 12s	1	16	0
Power, 7·5 h.p. @ 1s		7	6
Handling		10	0
Maintenance and repairs		15	0
Supervision and overhead		15	0
Amortization, 10% of £3,500	1	1	0
	£6	5	6

Cost per ton green ore $\frac{£6.\ 5s.\ 6d.}{30} = 4s.\ 2d.$

FINISHING ROAST: Capacity per machine 90 tons per day.

Cost per day:	£	s.	d.
Oil for ignition	1	10	0
Labour, 3 men @ 12s.	1	16	0
Power, 70 h.p. @ 1s.	3	10	0
Handling and crushing	3	15	0
Maintenance and repairs	1	10	0
Supervision and overhead	2	5	0
Amortization, 10% of £3,000		18	0
Royalty @ 1s.	4	10	0
	£19	14	0

Cost per ton pre-roast $= \frac{£19.\ 14s.}{90} = 4s.\ 5d.$

TOTAL COST:

	£	s.	d.
30 tons green ore pre-roasted in multiple hearth furnace @ 4s. 2d. per ton =	6	5	6
30 tons green ore yield 28·2 tons pre-roasted material to which 2·8 tons green ore are added or 31 tons in all: 31 tons roasted in D. & L. @ 4s. 5d. =	6	15	10
Total cost =	£13	1	4

Green ore to Pre-roaster ...	=	30 tons
Green ore to D. & L.	=	2·8 „
Total green ore roasted	=	32·8 „

Hence total cost per ton green ore

$$= \frac{£13.\ 1s.\ 4d.}{32·8} = 8s.\ 2d.$$

In conclusion, the work outlined in this article indicates that by combining the most economical forms of muffle or reverberatory roaster and blast-roaster, each working within its most economical limits of sulphur content of the ore, the roasting of zinc sulphide ores can be satisfactorily and economically carried out. The estimate of cost furnished is believed to be reasonably conservative. The roasted product leaves the machine as a friable sinter which is easily crushed and works well in the retorts when crushed to pass through a ⅜ in. ring, giving an increased retort capacity. Certain precautions are necessary in order to get the best results on the blast-roaster, and these have been described in the foregoing.

Laterite.—The following corrections should be made in Mr. J. Morrow Campbell's articles on Laterite appearing in Vol. XVII:

- p. 72 col. 1 line 20, for "where" read "while"
- p. 76 col. 2 line 6, for "non" read "now"
- p. 125 col. 2 line 44, for "ironized" read "ionized"
- p. 127 col. 1 line 1, for "Nigu" read "Niger"
- p. 127 col. 1 line 56, for "laterite" read "lateritite"
- p. 222 col. 1 line 11, for "Péau" read "Péan"
- p. 222 col. 2 line 17, „ „ "Péan"
- p. 225 col. 2 line 14, for "laterite" read "lateritite"
- p. 226 col. 1 line 15, „ „ „ "lateritite"
- p. 228 col. 2 line 24, for "Chantard" read "Chautard"

MODERN AIR-COMPRESSORS.—I

By DAVID PENMAN, B.Sc., M.Inst.M.E.

INTRODUCTORY.—The rapid substitution of power drills for drilling by hand has led to increased enterprise on the part of manufacturers of air-compressors. As a consequence economy and efficiency in the compression of air for power purposes have improved considerably in recent years. Among the more important developments worthy of note are the advent of the high-speed compressor, the substitution of electric for steam driving, better designs of valves, improvements in methods of intercooling, and the successful introduction of the rotary or turbo-compressor. The size of the unit has increased enormously, for whereas not so long ago capacities of 3,000 to 4,000 cubic feet of free air per minute were considered large, we find now machines of the rotary form capable of dealing with 10,000, 20,000, and even as much as 50,000 cu. ft. per minute, as witness some of the latest installations in South Africa, England, and elsewhere. The subject is one of considerable interest and importance to the mining engineer, and it is felt that the moment is opportune for a general discussion, with more or less detail as may be thought necessary, of some of the points of outstanding interest in the design, arrangement, and operation of modern forms of air-compressors.

ARRANGEMENT OF COMPRESSORS.—Air compressors of the reciprocating type may be separated broadly into two classes, namely, slow-speed and high-speed. The slow-speed compressor is invariably arranged horizontally. In it the piston has a long stroke and the number of revolutions per minute may be from 60 to 90. If the compressor is two-stage, the low and high-pressure stages may be in a straight line, both pistons being on the same piston-rod, or they may be side-by-side with the flywheel between. With either arrangement, the space taken up is considerable.

In the so-called high-speed compressor the piston speed measured in feet per minute may be actually less than in the slow-speed compressor. The number of revolutions per minute, however, is very much higher—150 to 400—thus allowing a much shorter stroke for the same capacity. The air cylinders are generally arranged vertically and side by side, though in some forms the high and low pressure pistons may be worked in a straight line from a common piston-rod. The quick-revolution compressor, as it is more correctly designated, takes up little more than one-third of the space occupied by the slow-speed horizontal compressor of the same capacity. The foundation costs are consequently less, as is also the expenditure for housing. If forced lubrication of bearings is employed, the friction losses are extremely small, and the high inertia of the heavy quickly moving working parts aids the engine or motor over the heavy stress at the end of the compressing stroke, and so makes for smooth and satisfactory working. The increased momentum of the moving parts also makes it possible to use a lighter flywheel.

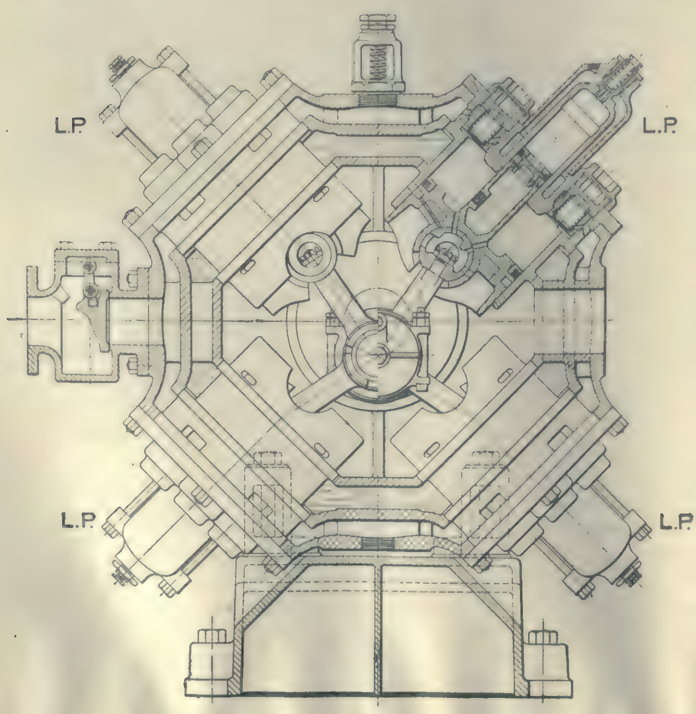


FIG. I. THE REAVELL SINGLE-STAGE COMPRESSOR.

The greater number of revolutions per minute allows electric motors to be coupled direct to the crank-shaft of the compressor, thus dispensing with the intermediate gearing which would be necessary with the slow-revolution type. As a result the overall efficiency of the electrically-driven quick-revolution set is higher than in the case of the slow-speed machine. That the advantages claimed for the vertical quick-revolution compressor as compared with the slow-speed horizontal form are admitted by manufacturer and user alike is shown by the fact that the majority of the reciprocating compressors recently installed are of the former type.

The vertical two-stage compressor, as has been already mentioned, has generally two cranks, one operating the low-pressure piston and the other the high-pressure piston. Two-stage vertical compressors having three and even four cranks have been built, however. In the latter form two low-pressure and two high-pressure cylinders are arranged in pairs on either side of the motor. In the three-crank type, there are two low-pressure and one high-pressure cylinders. The cranks are set 120° apart. This arrangement is costlier than the two-crank form, but the efficiency is higher. The variation in torque throughout a cycle is greatly reduced by having three cranks. When steam is the motive power, the engines are arranged under the air cylinders, the high-pressure steam cylinder being on the same piston rod as the high-pressure air cylinder, and similarly on the low-pressure side.

A vexed question in vertical compressors turns on the relative advantages of the trunk and ordinary pistons. Some makers claim for the trunk piston better air-tightness, greater durability, and an enhanced cooling effect. On the whole, however, the writer's experience has been that while in the single-crank type the differential trunk piston is almost imperative and works very satisfactorily, in the larger sizes of the two-crank or three-crank forms, the ordinary piston is to be preferred. In the Reavell compressor (Fig. 1), in which the cylinders are arranged radially around the shaft, trunk pistons are used. The trunk-piston compressor is, of course, single acting except where, as in the Sentinel compressor, the 1st stage compression takes place in front of the piston, and the 2nd stage in the annular space behind the piston.

In Broom & Wade's compressor (Fig. 2) trunk pistons are used, and the machine is single-acting. The inlet valve is mechanically operated. A wiper worked by a link off the connecting rod of the compressor actuates a cam, which at the correct point in the stroke operates a small bell-crank which pushes open the valve against the action of a spring. The delivery valve is of the automatic plate form. The machine is chiefly built for single compression up to from 50 to 90 lb. per square

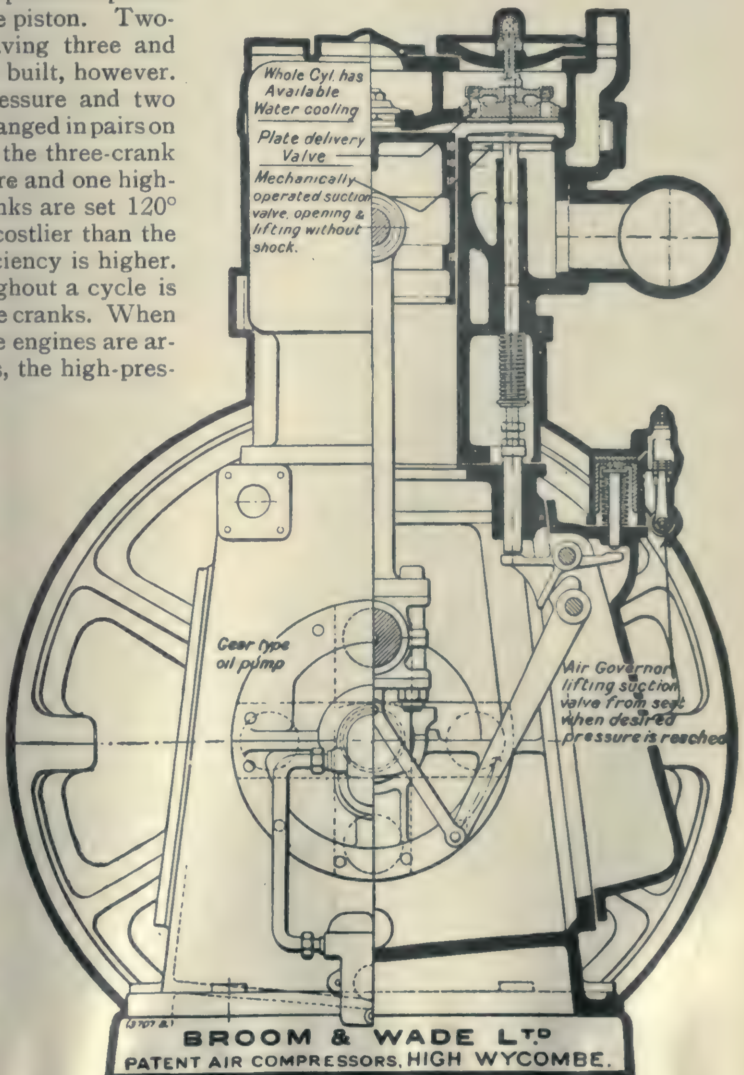


FIG. 2. THE BROOM & WADE SINGLE-STAGE COMPRESSOR.

inch, and is much used for relatively small outputs. The compressor is very effectively cooled, and forced lubrication is used. The output of the machine is controlled by an air-governor which lifts the suction valve from its seat when the normal working pressure in the receiver is exceeded. In the Belliss, Robey, Brotherhood, and various other makes, the shallow piston is employed. The arrangement of the tandem, duplex, and cross-compound forms of horizontal compressors need not here be enlarged upon, as those types will probably be familiar to most readers of this magazine.

A form recently introduced by the Sullivan Company and termed by them the "angle-compound" compressor, is sufficiently novel to be worthy of notice. This compressor is shown in section in Fig. 3. It has the low-pressure air-cylinder placed horizontally and the high-pressure air-cylinder vertically. The two connecting-rod ends are placed side by side on the same crank-pin. The pistons as well as the cylinders are thus 90° apart, that is, the high-pressure piston is at one end of its stroke when the low-pressure piston is midway in its cylinder. This design has been adopted to secure accurate balancing of the reciprocating masses. Since the inertia of the moving parts is proportional to the square of the speed of rotation, proper balancing becomes of greater importance in the quick-revolution compressor than in the slow-speed machine. In the angle-compound compressor the disturbing influences of the horizontal and vertical members tend to neutralize each other, the maximum unbalanced effects of the horizontally-moving parts occurring when those of the vertically-moving parts are at their lowest value, and vice versa. Balancing weights attached to the crank still further smooth down the variation of inertia throughout a revolution. The design has proved to be very successful and has given good results at speeds of from 200 to 250 r.p.m.

The proper lubrication of the compressor has an all-important bearing on the efficiency, continuity of working, and the life of the machine. Only the best kind of light, high-flash-point oil should be used for the cylinders, and just sufficient to effectively lubricate. Forced lubrication of all bearings is now adopted on most quick-revolution compressors. On this system the oil is supplied to the bearings under pressure from a pump operated from the crank shaft. A thin film of oil is in this way maintained between the shaft and its bearing, so that the working parts are prevented from making actual contact. The alternation of stress on the two halves of the bearing allows one side to be supplied with fresh lubricant while the oil is being squeezed out from the other half. The system is admirable and reduces friction and wear and tear to a minimum.

The position of the compressor in the engine-room should be chosen so that the connection to the inlet from the outside shall be as short and straight as possible.

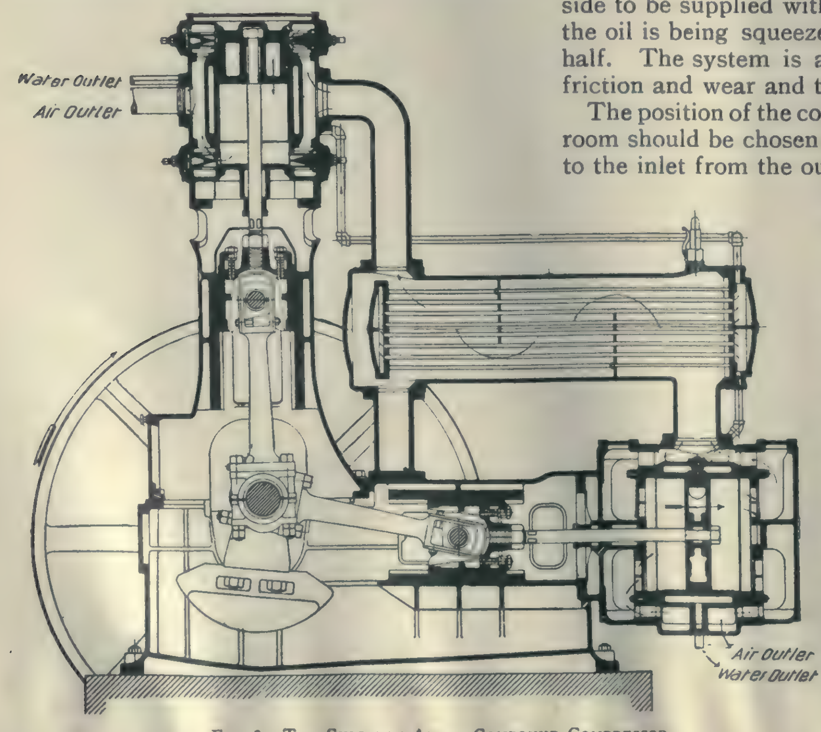


Fig. 3. The Sullivan Angle-Compound Compressor.

The Valves.—The higher rotative speeds used in modern air-compressors has necessitated the employment of valves the inertia of which is low and which give ample port-opening with a very small lift. The ordinary hinged and poppet forms, which have done and are still doing good work where the number of revolutions per minute is moderate, have been found inadequate and wasteful when used on the quick-revolution type of compressor. The plate or grid form of valve has been devised to meet the requirements and has been found admirably suitable for all types and sizes of high-speed compressors. The majority of manufacturers of modern air-compressing machinery have adopted this form of valve in their machines. The chief advantages are, reliability, noiselessness in operation, promptness of opening and closing, and great durability.

Briefly, the plate valve consists of thin finely-tempered steel plates in which are cut concentric or parallel slits which close over corresponding grids forming the seats of the valves. As an example of this type of valve, the form fitted to the Walker compressors may be quoted. They consist of circular steel plates, specially tempered, with concentric ports or openings, and with one side ground to a true face. The seatings are also circular and have openings corresponding with the bars in the valves. The valve proper weighs a few ounces only. The arms of the valve are in two pairs and these cross each other diametrically. The arms are made of special alloy and are waved or corrugated to permit of extension and contraction taking place without distortion of the valve. This design ensures movement of the valve parallel to its seat, thus eliminating friction and promoting smoothness of action. As a stop and cushion to the valve during action, a light guard of steel with arms waved in a fashion similar to the arms of the valves is provided. The valves are arranged at one end of the air cylinders as shown in Fig. 4. There are four inlet and four outlet valves to each cylinder.

The valves used in the Belliss & Morcom compressor are of similar design and are shown in detail in Fig. 5. In the illustration, (1) is the valve seat and (2) the valve guard, both of cast iron. In the recesses on the valve guard are placed the springs (3) which control and close the valve. The valve plate (4) is made of tempered steel plate approximately $\frac{1}{16}$ in. thick and is perforated as shown. The parts of the valve marked (8) are specially tempered and ground down to form springs to perform the same function as the corrugated cross-arms of the Walker valves. The completed valve

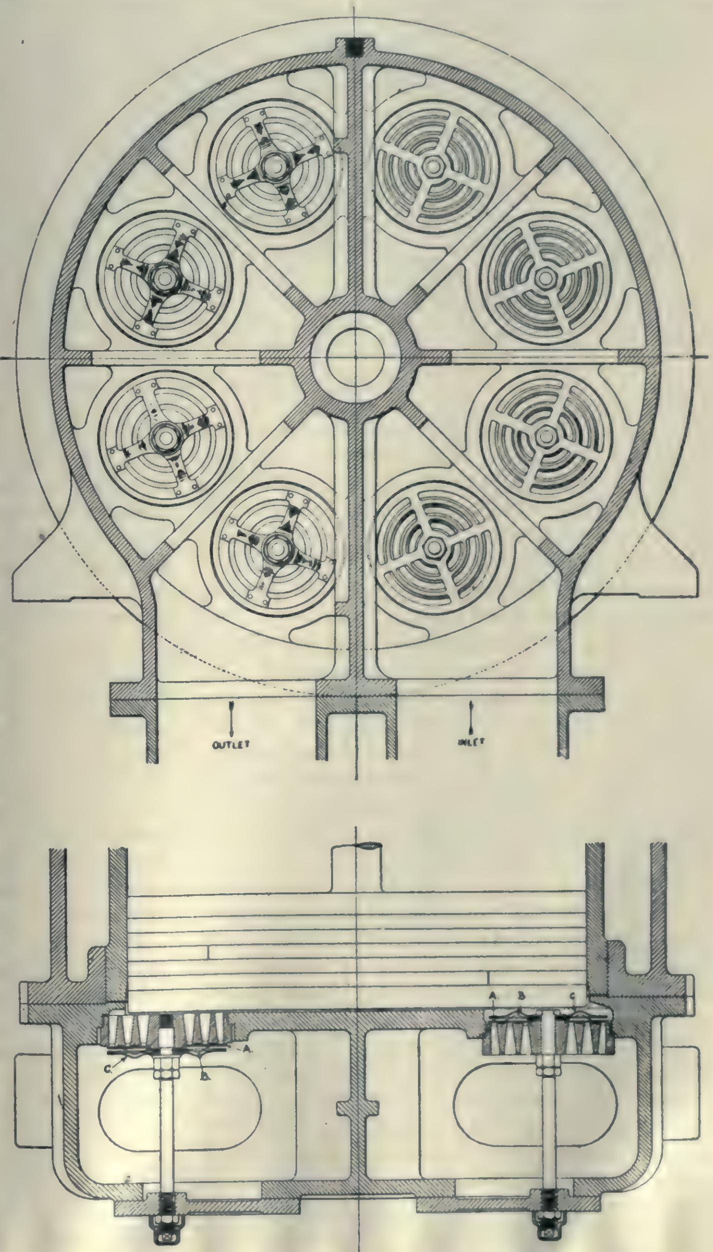


Fig. 4. The Arrangement of the Valves in the Walker Compressor.

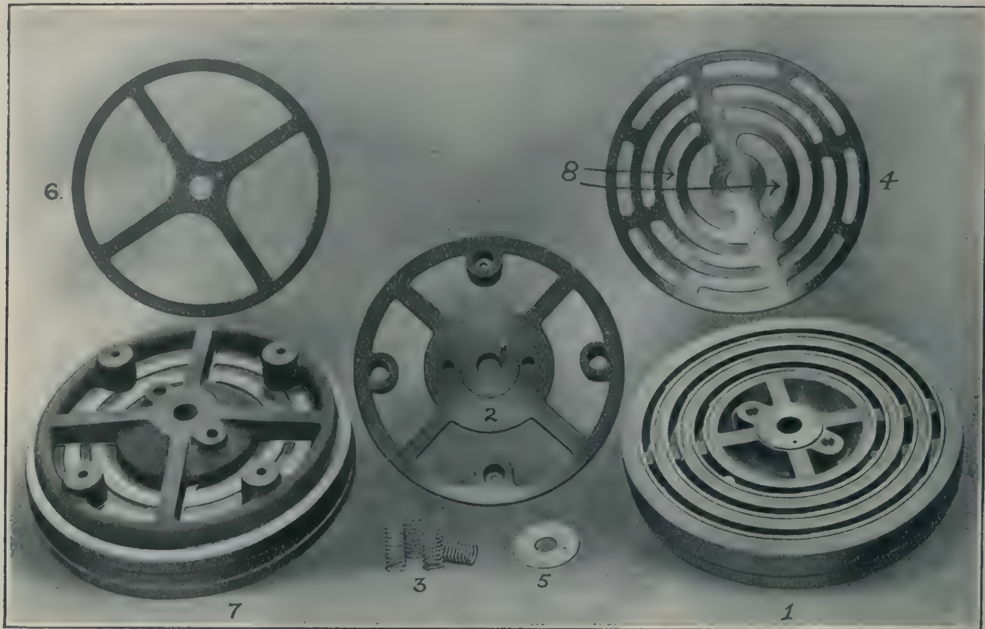


FIG. 5. THE BELLISS-MORCOM VALVES.

with the parts arranged in position is shown at (7). The total lift of the valve is only about $\frac{1}{16}$ in. The valves are placed in a chamber at the side of the cylinder, leaving the ends free for water-jacketing. Plate valves of a somewhat similar design to those described are used in the Robey, Brotherhood, Ingersoll-Rogler, and other well-known compressors.

The Ingersoll - Rogler valves are placed radially in each end of the cylinder barrel. The inlet valves are placed underneath, and the discharge valves above the cylinder. In the larger compressors there are two and sometimes three inlet and discharge valves at each end of the cylinder. In small machines only one inlet and one discharge valve are used at either end of the cylinder.

The valves on the Sullivan "angle-compound" compressor are also of the plate type, but the design is radically different from those described above. It consists of a group of thin, flat fingers, or blades, made from special rolled spring steel (Fig. 6). The valves are rigidly bolted at one end only to a steel guard, and are perfectly free at their other end. The fingers, being very flexible, are bent or lifted by the incoming or outgoing air; and they are bent or rolled over curved stops on the guard plate. Thus, in opening, the fingers exercise a rolling or rocking action against the guard, the lifting commencing first at their outer ends. In closing, the fingers roll back on the grid which forms the seat of the valve. The advantages claimed for this "end rolling" action are that it is free from any bodily lift that would produce a hammering or slapping effect, and that it tends to secure freedom from breaking and leakage. The valves are set in plates or end walls situated between the cylinder barrel and the heads, the inlet valves being in the lower half and the discharge valves in the upper half. In the high-pressure cylinders the valves are placed in cages and arranged radially round the periphery of the cylinder heads.

The mechanically-operated valve is also used to a considerable extent in high-speed compressors. Its use is generally confined to inlet valves, as in the Ingersoll "Imperial" compressor, and various designs of Sullivan machines. In those compressors the discharge valves on both low-pressure and high-pressure cylinders are of the poppet type. In Bailey's "Köster" compressor a mechanically-operated piston valve is used which controls three points on the cycle, namely, the beginning and the end of the suction stroke, and the end of the discharge stroke. The opening of the discharge, which is the variable point in the cycle, is controlled by an automatic spring valve. The arrangement is unique and works well.

MOTIVE POWER.—During recent years the rapid development of the electric motor for operating machinery has been a notable feature in the mining industry. For actuating air-compressors, the electric drive has the characteristic advantages of compactness, flexibility, ease of starting and control, reliability, and high efficiency over a wide range of loading. In many cases, of course, it may not be desirable to install an electric plant for the sole purpose of being able to use the electric motor as an intermediate link between the prime mover and the compressor. For small isolated plants it is undoubtedly better to drive the compressor direct by a steam engine, as in such cases the cost of plant and the losses incurred in the conversion of steam to electric power would probably far outweigh the advantages to be gained thereby. But where electric power can be generated or purchased cheaply there can be no question that the electric motor is the best means of driving the compressor.

In districts where mines are numerous it will always pay to generate electricity on a large scale in some central position, where cheap fuel and abundant supplies of water are available, and distribute the energy electrically to the various mines. The over-all efficiency is much higher than it would be in the case of each mine producing its own power whether as steam or as electricity. In large units, electric power may be generated at as low a consumption of high-pressure steam as 13 lb. per kilowatt-hour. Allowing for a loss of 20% in transmission and in the motor, which should be ample in most cases, this works out at about 12 lb. of steam per hour per brake-horse-power of the motor. Few steam engines driving compressors can approach this, the best probably taking anything from 15 to 20 lb. of steam per b.h.p. per hour. In addition to a saving in cost of power there is less initial outlay involved and lower costs for attendance.

Where the compressor is installed in the mine itself, an arrangement which is becoming increasingly popular, it becomes practically imperative to use electric drive. The advantages to be gained by having the compressing plant underground are chiefly comprised in the saving in the cost of cable as compared with the cost of piping, the higher efficiency of the electric than the air transmission, and the reduction in the cost and trouble of maintaining the transmission line against leakage. Whether the compressor is situated above or below ground, it is generally best to couple the motor direct to the compressor without the intervention of gearing. The slow-speed motor is of course larger and costlier than the high-speed motor, but direct coupling makes for more satisfactory working and higher efficiency. The slow-speed motor, it should be further noted, can be designed to give a greater margin against sparking, with a longer life of commutator and brushes, this with reference to direct-current machines. The speed of quick-revolution compressors may be anything from 150 to 350 r.p.m. Where a direct-current supply is available, practically any speed of motor can be obtained, and thus there is generally little difficulty in securing a motor whose speed is suited to that for which the compressor is designed. If a high-speed motor is adopted, belt-drive or internal-toothed gearing is generally found satisfactory. If the supply is alternating current two types of motors are available, namely, the synchronous, and the induction motors. The former gives constant speed at all loads, while the speed of the latter falls off slightly as the load increases. The induction motor is most generally employed for reciprocating compressors. It is easily started, is small and compact for its output, has no commutator difficulties, and runs with very little attention.

FIG. 6. THE SULLIVAN VALVES.

Gas and oil engines are also now being used for driving air-compressors, units up to 500 h.p. having been recently put into operation. Where supplies of cheap gas are available, as from blast-furnaces and coke-ovens, the gas-engine forms an economical prime mover. Gas producers using cheap fuel form another ready means of obtaining an inexpensive supply of gas for the engines. The reliability of the gas engine has been improved enormously of recent years, and the best makes approach the steam engine in this respect.

OUTPUT CONTROL.—The regulation of the

output of the compressor to the variation in the demand for air is a matter of great importance in mining practice. At one time the number of drills in operation simultaneously may approach the maximum possible, while at another few or none at all may be working. Thus the demand for air may vary from nothing up to the full capacity of the compressing plant. Not only so, but the fluctuations may be very abrupt, so that only a few minutes or even seconds may suffice to produce a change from a small demand to a relatively large one. The pressure in the mains must not be allowed to fall appreciably; indeed, it should be maintained practically constant whatever the quantity of air utilized, so that the compressors must be capable of supplying an increased demand with inappreciable delay. On the other hand, as soon as the demand for air begins to fall off, the output of the compressor must simultaneously decrease, in order to prevent waste of power.

In the case of steam-driven compressors, the method of speed control generally adopted consists of a centrifugal speed-governor actuated from the crank-shaft and operating a throttle-valve in the steam-inlet. This governor controls the output for all pressures below and up to the full working pressure, the speed of the compressor on that range being a maximum, provided the steam pressure is maintained. If the pressure in the receiver rises above normal, the speed is now controlled by an air-governor, which automatically adjusts the speed of the compressor to the demand for air. Such a method of speed control operates between a maximum speed and the permissible minimum speed. For a variation of about 5% above or below the normal working pressure, the speed may be varied from say 250 r.p.m. as a maximum to about 50 r.p.m. as a minimum. The method is extremely economical and can hardly be improved upon.

One disadvantage of electric motors is that in general they cannot be quite so easily or economically regulated for speed as the self-contained steam engine. The direct-current motor may of course be automatically varied in speed by having an air-relay operated from the receiver, the relay actuating a rheostat which varies the current in the shunt winding of the motor. With the alternating current motor, however, economical variation of speed cannot well be obtained, except in special cases.

In the "Empire" control system, the arrangement of which is shown diagrammatically in Fig. 7, the output is adjusted to the demand in the following manner. The equipment consists of a pressure and a speed regulator and an unloading device. The pressure regulator consists of the Bourdon gauge (A) having a silver-tipped lever operating between two silver-tipped contacts. The gauge is connected direct to the receiver by piping as shown. When the pressure in the receiver is at the working value, the lever takes up a position between the contacts but touching neither. Suppose the compressor to be standing with the receiver full of air at the working pressure. When the pressure falls a small amount below the working value, the lever swings over to one contact and closes the circuit of the relay (B), which in turn closes the main relay, putting the motor on to the electric supply and so starting the compressor. On the other hand, should the pressure rise above the working value, the lever of the gauge swings over to the other contact, and the relay switch is again energized, but caused to open this time, thus stopping the motor. No electrical circuit is broken at the contacts on the pressure gauge, and thus they cannot be burned or destroyed. The relay is fitted with a device which breaks its own circuit each time it operates, so that the small relay coil is only excited for an instant at a time. The regulator can, of course, be used with either alternating or direct-current motors. As described, the device can only be used on small machines which do not take more than 10 amperes. For larger compressors a controller is required in order to limit the starting current. The starter is operated automatically by having the main contacts of the pressure regulator relay in series with the controller solenoid, so that when the relay opens, this opens the controller and stops the motor. Similarly, when the relay closes, this operates the controller and starts up the motor. The method of varying the speed of the motor when running consists, in the case of direct current machines, of automatically varying the shunt resistance of the motor. Various methods, suited to the range of speed regulation required, may be adopted. Speed variations of 200 to 300% may be obtained in this way. In the case of polyphase induction motors, two economical speeds may be obtained by using a "Cascade" type of motor. The ratio of the two speeds is frequently 2 to 1, the higher speed being used during the periods of the day when the output is high, and the lower speed during less busy intervals. Another system which may be adopted on an alternating current supply is the use of a motor having two sets of pole windings. The speed of an induction motor is inversely proportional to the number of poles, so that with two sets of windings on the stator two distinct speeds may be obtained.

Owing to the extra cost and the greater complexity, however, it is preferable to run electrically-driven compressors at constant speed, and to control the supply of compressed air by means of an automatic output regulator. The devise used on "Sentinel" compressors is shown in Fig. 8, a similar arrangement to that used on many other machines. It is fitted in the inlet pipe. Air pressure is communicated from the receiver to the spring-loaded diaphragm (A). When the pressure in the receiver exceeds the predetermined limit, the diaphragm is pressed back, opening the valve (B) and allowing the air pressure to close the throttle valve (C) by pushing the piston upward against the controlling action of the spring which normally keeps the valve open. On the receiver pressure falling below the normal, the pilot valve (B) closes and, as the air-pressure is released, the control valve (C) is pulled open. When the throttle valve is shut, the piston simply travels to and fro in the cylinder without drawing in or delivering air. Thus the no-load losses are practically limited to the no-load friction losses. The control valve does not act gradually but acts so that the inlet passage is either fully open or completely closed. The action is prompt and positive, and this is found to be more economical than a gradually throttling action. The pilot valve may be adjusted so as to operate at any plus or minus pressure from the normal working value.

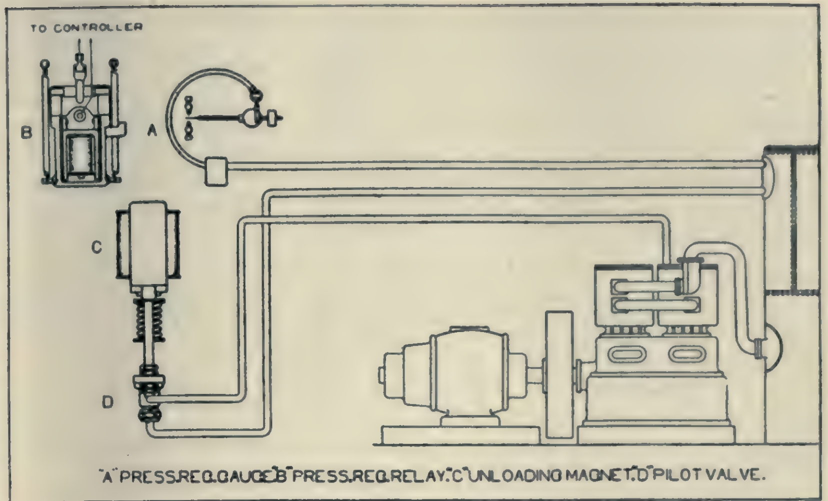


FIG. 7. THE "EMPIRE" CONTROL SYSTEM.

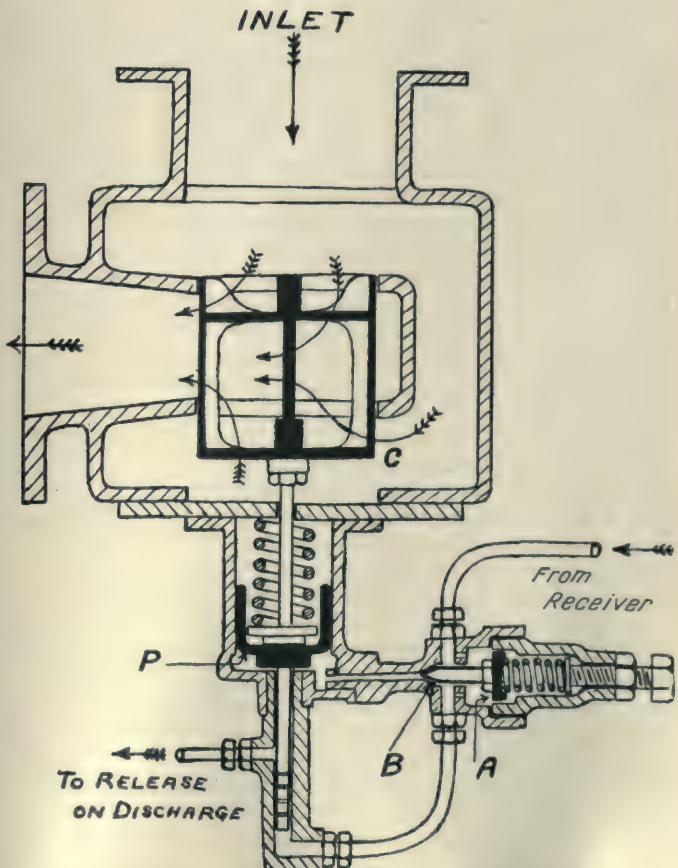


FIG. 8. THROTTLE-VALVE CONTROL FOR "SENTINEL" COMPRESSOR.

When the compressor is motor-driven, it is generally found desirable to provide a special unloading device in order to allow the motor to start easily. Especially is this the case with large motors. The starting current, if the receiver is full, may be anything from one-and-a-half times to twice full-load current. It is important to be able to reduce this consumption of current to well under full-load current. This is best done by using a special unloading valve. In the "Empire" control systems already referred to (Fig. 7), the unloading valve (not shown) is actuated by the pilot valve (D) which is operated by the electro-magnet (C). The pressure regulator (A) closes at the minimum pressure limit, and this energizes the pilot-valve magnet which, operating the unloading valve, releases the pressure on the discharge side of the compressor and so allows the compressor to start up easily. On reaching full speed the pilot-valve circuit is opened and the load applied.

(*To be continued*).

THE EVOLUTION OF ORE DEPOSITS FROM IGNEOUS MAGMAS

By W. H. GOODCHILD, A.R.S.M., M.Inst.M.M., F.G.S.

(Continued from the May issue, page 249).

The Constitutions of the Principal Rock-Forming Minerals.

The problem of the constitutions of the natural silicates and their associates has been the subject of many investigations, the names of several of the world's ablest chemists being identified with researches on these substances.

Hitherto research has been largely concerned with attempts to assign various kinds of chemical formulae, structural and otherwise, to the rock-forming minerals. One of the most recent contributions in this direction is that by the Drs. Asch, of Berlin,* who have endeavoured to give structural formulae based on the hexite-pentite or ring theory and so to bring the chemistry of the silicon compounds more or less into line with that of the carbon compounds. It is, however, possible to approach the subject on somewhat different lines from those that have been pursued hitherto, and to do so without committal to any of the more hypothetical notions that have been promulgated from time to time to explain the construction of the minerals. All students of mineralogy are familiar with the strings of chemical analyses of such complex minerals as the amphiboles, pyroxenes, micas, etc., that appear in the text-books. Among the most striking features of these chemical complexes are the seemingly erratic and unaccountable variations in density or volume that they display even among different specimens of the same species, with approximately identical compositions.

Little or no attention has been directed hitherto to the systematic study of the volume aspects of the common silicates that go to build up the great masses of rock from which our ore deposits are derived. Some silicates are described as "heavy" and some as "light" and there the matter ends. The densities of the rock-making minerals, and consequently those of the rocks which they form when aggregated together, are at present little better than a miscellaneous collection of curious and uncoördinated facts, while the theories that are concerned with abstract chemical formulae cast very little light on these matters. We shall therefore approach the problem from the viewpoint of the volume relationships of the various rock-making minerals.

It can scarcely be expected that any very detailed explanation of these volume variations can be accomplished without a great deal of research directed specifically to the elucidation of the phenomena. Nevertheless it is possible to get some insight into the inner meaning of some of these variations, and the results are of vital importance to the general theory of magmatic differentiation and the formation of ore deposits from rock magmas. Tables of the S.V.S. of the rock-forming oxides were given in the May article and a graph showing a periodic relationship between the S.V.S. and formula or combining weights. At first sight it does not appear that the densities of the various oxides are anything more than an unrelated or miscellaneous collection of figures. In the following Table I. are given a number of the simpler volume relationships that subsist between the various oxides in their different forms, and such substances as common salt, sodium sulphate, and others which enter into the composition of many common rock-making silicates. With the facts of isomorphism in mind these volume relationships

*The Silicates in Chemistry and Commerce, by Dr. W. Asch and Dr. D. Asch. Translated by A. B. Searle.

TABLE I. VOLUME RELATIONS OF ROCK-FORMING OXIDES AND ASSOCIATED COMPOUNDS.

Anhydride Forms.

$$\underbrace{\underset{11\cdot1}{1\,\mathrm{MgO}} + \underset{14\cdot5}{1\,\mathrm{FeO}}}_{25\cdot6} = \underset{25\cdot5}{1\,\mathrm{Al_2O_3}}$$

$$\underbrace{\underset{22\cdot2}{2\,\mathrm{MgO}} + \underset{14\cdot5}{1\,\mathrm{FeO}}}_{36\cdot7} = \underset{=\,36\cdot6}{1\,\mathrm{K_2O}}$$

$$\underset{22\cdot2}{2\,\mathrm{MgO}} = \underset{22\cdot2}{1\,\mathrm{Na_2O}}$$

$$\underset{11\cdot1}{1\,\mathrm{MgO}} + \underset{25\cdot5}{1\,\mathrm{Al_2O_3}} = \underset{36\cdot6}{1\,\mathrm{K_2O}}$$

$$\underset{16\cdot4}{1\,\mathrm{CaO}} = \underset{16\cdot0}{1\,\mathrm{FeO_2}}$$

$$\underbrace{\underset{16\cdot0}{1\,\mathrm{CaO}} + \underset{14\cdot5}{1\,\mathrm{FeO}}}_{30\cdot9} = \underset{30\cdot5}{1\,\mathrm{Fe_2O_3}}$$

$$\underbrace{\underset{49\cdot2}{3\,\mathrm{CaO}} + \underset{29}{2\,\mathrm{FeO}}}_{78\cdot2} = \underset{77\cdot7}{7\,\mathrm{MgO}}$$

$$\underbrace{\underset{49\cdot2}{3\,\mathrm{CaO}} + \underset{22\cdot2}{2\,\mathrm{MgO}}}_{71\cdot4} = \underset{72\cdot5}{5\,\mathrm{FeO}}$$

$$\underbrace{\underset{16\cdot4}{1\,\mathrm{CaO}} + \underset{29}{2\,\mathrm{FeO}}}_{45\cdot4} = \underset{44\cdot4}{4\,\mathrm{MgO}}$$

$$\underbrace{\underset{16\cdot4}{1\,\mathrm{CaO}} + \underset{25\cdot5}{1\,\mathrm{Al_2O_3}}}_{41\cdot9} = \underbrace{\underset{11\cdot1}{1\,\mathrm{MgO}} + \underset{30\cdot5}{1\,\mathrm{Fe_2O_3}}}_{41\cdot6}$$

Hydrate Forms.

$$\underset{81}{2\,\mathrm{K_2O}} = \underset{81\cdot9}{3\,\mathrm{Al_2O_3}} = \underset{81\cdot9}{3\,\mathrm{Na_2O}} = \underset{81}{3\,\mathrm{Na\,Cl}} = \underset{81\cdot6}{3\,\mathrm{Al\,F_3}} = \underset{85}{(\mathrm{Na_2B_4O_7})}$$

$$\underset{40\cdot5}{1\,\mathrm{K_2O}} = \underset{40\cdot2}{1\,\mathrm{Na_2CO_3}} = \underset{42\cdot6}{3\,\mathrm{Li_2O}}$$

$$\underset{27\cdot3}{1\,\mathrm{Na_2O}} = \underset{27\cdot3}{1\,\mathrm{Al_2O_3}} = \underset{27\cdot6}{1\,\mathrm{KF}} = \underset{28\cdot4}{2\,\mathrm{Li_2O}} = \overbrace{\underset{27}{3\,\mathrm{H_2O}} = \underset{28\cdot8}{\mathrm{B_2O_3}} = \underset{28}{2\,\mathrm{NaF}}}^{\text{In Combination}}$$

$$\underbrace{\underset{23\cdot4}{1\,\mathrm{CaO}} + \underset{=\,27\cdot3}{1\,\mathrm{Al_2O_3} \text{ or } 1\,\mathrm{Na_2O}, \text{etc}}}_{50\cdot7} = \underset{49\cdot6}{4\,\mathrm{MgO}}$$

$$\underset{54\cdot6}{2\,\mathrm{Al_2O_3}} = \underset{54\cdot6}{1\,\mathrm{Na_2SO_4}} = \underset{54\cdot6}{2\,\mathrm{Na_2O}}$$

$$\underset{40\cdot5}{1\,\mathrm{K_2O}} = \underset{40\cdot0}{1\,\mathrm{B_2O_3}} \text{ (free oxide)}$$

$$\underset{93\cdot6}{4\,\mathrm{CaO}} = \underset{94\cdot8}{3\,\mathrm{Na_2S}}$$

1 H_2O combined as monohydrate of Al_2O_3 = 9 (approx.)
B_2O_3 combined in $Na_2B_4O_7$ = 28·8
NaF combined in Cryolite = 14

are altogether too significant to leave any room for doubt that volume relationships are important factors in the constructional processes that operate in the crystallization of complex rock minerals from the magmas. Although no relationships are shown in this table between hydrate and anhydride forms it is probable that both hydrate and anhydride forms are built together in some instances into complex silicates. Vesuvianite seems to afford an instance of this. Just as there is a broad general order of separation of the oxides from a magma beginning with those oxides that have the smaller S.V.S. and are insoluble in water and proceeding to the soluble end of the series, so there appears to be an order of conversion from the anhydride to the hydrate form. This order is the reverse of the crystallization order. That is to say, it is the order of diminishing aqueous solubility and proceeds from potassium oxide to magnesia with the same kind of reservations in regard to alumina as in the case of the crystallization order. The graph of S.V.S. previously given read from right to left, that is, from large to small S.V.S., therefore gives broadly the general order of hydrolytic expansion, and the diagram showing the quadrants of the spheres puts this information in a form suggesting the expansions of liquid bubbles. The survey of the volume relationships of the rock-forming minerals asdiplayed in Tables II. to X. indicates that unhydrolysed potash is such a rarity in igneous rocks as to be practically a negligible quantity, while at the other end of the series magnesia occurs for the most part unhydrolysed in fresh igneous rocks, its hydrolysis taking place after crystallization in such processes as serpentinization.

Alumina appears in both forms, much of it being unhydrolysed as in the pyroxenes, but possibly the larger portion exists in the hydrolysed form in felspars if the preponderance of felspars in the upper regions of the great batholiths is any real guide to the true proportion of felspathic to non-felspathic constituents in the batholiths as a whole, a point which may well be left open. Soda is predominantly hydrolysed, the soda amphiboles and similar minerals, which are probably non-hydrolysed, being rarities as compared with soda felspars and felspathoids. Lime is more or less evenly divided in most calcic rocks, bulking largely both in pyroxenes and felspars, except in anorthosite, which is an entirely hydrolysed type of rock.

It appears therefore that the hydrogen concentration in a rock magma is so arranged as to be considerably short of that required for the complete conversion of the anhydride into the hydrate forms. Taking this in conjunction with the order of hydrolytic expansion leads to the conclusion that it may be possible for complex minerals to occur in which only a portion of the bases are hydrolysed. Lime occurs toward the magnesia end of the series, and it is worthy of note therefore that 1 MgO, 11·1 + 1 CaO, 16·4 = 27·5 (anhydride forms), approximately the figure which is the most striking feature of the hydrate series. In connection with these different forms it should be borne in mind that the hydrogen does not necessarily appear in the mineral, while experimental evidence based on anhydrous melts indicates that the silica concentration may also play an important part in determining the form of the base, whether it be the anhydride or hydrate form, in the crystallized product. Expansion of anhydride to hydrate forms cannot therefore be solely ascribed to hydrogenation, though it is

TABLE II. TITANIUM MINERALS.

Mineral		Chemical Composition (a) Formula wt. of Oxide (b) S.V.S. of Oxide		Sp. G. of Mineral	S.V.S of Mineral	Sp. Gr. of TiO_2	S.V.S. of TiO_2	Remarks
Geikielite		MgO	TiO_2					
	(a)	40	80	4·0	30·0	4·35	18·3	Contains not less than 8% $FeO + Fe_2O_3$ which is allowed for in computation.
	(b)	11·1	—					
Ilmenite		FeO	TiO_2					Ilmenite containing Fe_2O_3 shows variations in Sp. G. analogous with those shown by Pseudobrookite.
	(a)	72	80	4·7	32·3	4·47	17·8	
	(b)	14·5						
		CaO	TiO_2					Compare S.V.S. of TiO_2 with S.V.S. of SiO_2 in lime pyroxene as deduced from Diopside (17·9).
Perofskite	(a)	56	80	4·0	34·0	4·53	17·6	
	(b)	16·4						
Pseudobrookite		2 Fe_2O_3	3 TiO_2	4·4	127	3·65	22·0	S.V.S. 127 = approx. 4 × S.V.S. Ilmenite.
	(a)	320	240	4·98	112	4·85	17·0	
	(b)	61						
		FeO	TiO_2					
Picro-ilmenite		MgO } 1	80	4·0	—	4·0	20·0	Computed from analysis by T. Crook 57·64% TiO_2, 16·57% FeO, 10·17% Fe_2O_3 15·56% MgO.
		Fe_2O_3						
Pyrophanite		MnO	TiO_2					MnO has less compressive power than MgO, FeO, or CaO.
	(a)	71·0	80	4·54	33·3	4·15	19·3	
	(b)	14·0						
Titanite and		CaO	TiO_2	3·4	57·6	SiO_2	SiO_2	Formula CaO, TiO_2, SiO_2
Guarinite	(a)	56	80	3·56	55·0	2·66	22·6	TiO_2 assumed to have same S.V.S. as in Perofskite
	(b)	16·4	17·6			2·86	21·0	

doubtless safe to infer that increase of hydrogen concentration tends to drive the dense into the expanded forms. Additional heat must be supplied if the change is to take place in the reverse direction, and this is the condition which is realized to varying degrees in the metamorphism of sedimentary rocks in the neighbourhood of masses of rock magma.

In discussing the constitutions of the sulphide minerals that occur at Sudbury the assumption was made that the lower sulphide retained its own S.V.S. and that the complex sulphides were derived from the simple monosulphides by the action of these on a further quantity of sulphur, the volume or Sp. Gr. of the minerals depending on the compressive or expansive action of the mono bases operating on the electro-negative radical, sulphur. The justification of the assumptions was shown by results given in various tables, and it was found possible to definitely correlate the volumes occupied by certain monosulphides with properties of their corresponding metals which were closely related to the internal pressures, and consequently to the surface tensions, of the metals. In the case of the silicates we shall make the same assumptions, namely, that the basic oxides retain, at any rate approximately, their own S.V.S. and operate on the electro-negative radical silica, compressing it or expanding it as the case may be. It should be borne in mind in this connection that free silica resembles sulphur in its large number of allotropic modifications having different densities and crystalline forms. It is not possible in the present state of knowledge to correlate the expansions or contractions with internal pressure or surface tensions; nevertheless the justification for the assumptions is to be found in the results. We thus treat the subject of silicate densities in terms of the fundamental conceptions of pressure and volume. In evaluating the densities of the various minerals in this way the facts of allotropy have to be duly considered, and it may reasonably be asked how the form of the basic oxide is to be determined. In some cases this is admittedly a difficult matter. Moreover, dynamic allotropy introduces a further difficulty, for if a mineral may contain a proportion of its lime, for instance, in the dense or anhydride form and the remainder in the hydrate form, it is not possible at present to determine the relative proportions of the two. It seems probable that some of the minor variations in density will ultimately be found to be due to dynamic allotropy. The main problem is, however, by no means so difficult as might appear at first sight.

It is definitely established that the conversion of anhydride to hydrate forms is accompanied by an evolution of heat; that is to say, the energy of the anhydride form is greater than that of the hydrate. Generally speaking, therefore, where we get a high compression of SiO_2 it is safe to infer that the basic oxides are present in the more energetic or anhydride form. Thus a preliminary computation gen-

TABLE III. PHOSPHATES.

Mineral	Chemical Composition (a) Formula wts. of Oxides (b) S.V.S. of Oxides			Sp. G. of Mineral	S.V.S. of Mineral	Sp. G. of P_2O_5	S.V.S. of P_2O_5	Remarks
Calcium Phosphate (a) (b)	3 CaO 168 49·2	P_2O_5 144 –	—	3·05	102·3	2·7	53·1	Approx. equal Vols. CaO and P_2O_5 Compare S.V.S. P_2O_5 in Fluor-Apatite
Fluor-Apatite (b)	3(3CaO) 3 × 49·2	3(P_2O_5) —	CaF_2 25	3·16	319	2·94	49·1	S.V.S. CaF_2 is approx. ½ S.V.S. 3CaO
Chlor-Apatite (b)	3(3CaO) 3 × 49·2	3(P_2O_5) —	$CaCl_2$ 50·2	3·16	332	3·23	44·6	S.V.S. $CaCl_2$ approx. equal to 3 CaO
Monazite (a) (b)	Ce_2O_3 328 50	P_2O_5 —	—	5·2	91	3·50	41·0	*Calculation only approximate as Sp. G. of Ce_2O_3 based on Sp. G of La_2O_3
Xenotime (a) (b)	Y_2O_3 227 44·5	P_2O_5	—	4·55	81·5	3·9	37·0	——

TABLE IV. SPINEL GROUP.

Mineral	Chemical Composition (a) Formula Weight (b) S.V.S. of Oxide		Total Formula Weights	S.V.S.s of Oxides Uncombined	Sp. G. of Mineral	S.V.S. of Mineral	Remarks
Chrysoberyl (a) (b)	BeO 25 8·4	Al_2O_3 102 25·5	127	33·9	3·5 3·84	36 33	Sum of low T oxides S.V.S.s = 35·7
Spinel (a) (b)	MgO 40 11·1	Al_2O_3 102 25·5	142	36·6	3·6	39·5	Sum of low T oxides 39·8.
Hercynite (a) (b)	FeO 72 14·5	Al_2O_3 102 25·5	174	40·0	3·95	44·0	Sum of low T oxides 41·8.
Gahnite (a) (b)	ZnO 81 14·4	Al_2O_3 102 25·5	183	39·9	4·6	39·8	S.V.S. same as Spinel.
Magnetite (a) (b)	FeO 72 14·5	Fe_2O_3 160 30·5	232	45	5·18	45	Almost same S.V.S. as Hercynite.
Hausmannite (a) (b)	MnO 71 14	Mn_2O_3 158 33·4	229	47·4	4·72 4·86	48·5 47·0	S.V.S. close to that of Chromite.
Chromite (a) (b)	FeO 72 14·5	Cr_2O_3 153 30·5	225	45	4·32 4·57	52·0 49·0	*Note* large expansion.

erally discloses which form to employ in the final evaluation.

The Drs. Asch distinguish between what they term "dynamized" and "disdynamized" silicates, and their classification into two types seems to agree with, in the main, the hydrolysed and unhydrolysed silicates as set forth in the accompanying tables. Their classification is based on the behaviour of the various silicates toward dilute acids, the dynamized silicates, which resist, and the disdynamized, which are attacked by dilute acids. The agreement is, however, only partial, for the micas, which are pre-eminently hydrolysed, at any rate to a considerable extent, resist acids. It is quite clear nevertheless that their "disdynamization" refers to allotropic change, for they say: "In order to understand the nature of the state of disdynamization produced when clays are heated to vitrification, it is necessary to assume that oxygen has two kinds of valency—primary and secondary—and that the bonding of the ring-radicals is due to both primary and secondary valencies of oxygen."* Now on heating a clay to vitrification there is an absorption of heat accompanying the change from the hydrate to the anhydride form of the alumina, so that it would appear to be more apt to put their terminology the other way round, since the energy of the system is increased or dynamized by the heat absorbed

* Loc. cit. p. 109.

TABLE V. GARNET GROUP. 3 RO. R_2O_3, 3 SiO_2.

Mineral		Chemical Composition excluding 3 SiO_2 (a) Formula wt. (b) S.V.S. of Oxide		Total Formula wts. of basic oxides	Total S.V.S. of basic oxides	Sp. G. of Mineral	S.V.S of Mineral	Calculated		Remarks
								Sp. G. of SiO_2	S.V.S. of SiO_2	
Pyrope		3 MgO	Al_2O_3							
	(a)	120	102	222	58·8	3·6	112	3·37	17·6	
	(b)	33·3	25·5							
Spessartite		3 MnO	Al_2O_3			4·05	122	3·30	18·2	Mean S.V.S. SiO_2 17·5 is approx. same as Pyrope.
	(a)	213	102	315	67·5					
	(b)	42	25·5			4·20	118	3·55	16·8	
Almandite		3 FeO	Al_2O_3			4·0	124·5	3·25	18·5	Mean S.V.S. SiO_2 = 17·8.
	(a)	216	102	318	69·0					
	(b)	43·5	25·5			4·15	120·5	3·50	17·2	
Grossularite		3 CaO	Al_2O_3			3.55	127·0	3·45	17·8	Vol. of 3 CaO closely approximates 3 SiO_2.
	(a)	168	102	270	74·7					
	(b)	49·2	25·5			3·66	123·0	3·70	16·1	
Andradite		3 CaO	Fe_2O_3			3·8	134	3·33	18·0	Mean S.V.S. of SiO_2 = 17·3.
	(a)	168	160	328	79·7					
	(b)	49·2	30·5			3·9	130	3·58	16·7	
Uvarovite		3 CaO	Cr_2O_3							FeO usually present. Compare chromite expansion.
	(a)	168	153	321	79·8	3·5	140	3·00	20	
	(b)	49·2	30·6							

and converted.

Their explanation in terms of oxygen valencies is also by no means convincing, for there is plenty of evidence to indicate that the allotropic change in the oxide may be connected with changes in the metallic constituent of the basic oxide, although this doubtless affects the oxygen.

Their theory of disdynamization, which is really the only part of their general ring-theory of silicate constitution that touches on the volume aspects of the silicates, is far from satisfactory, and raises serious doubts as to whether the ring-theory itself is at all an adequate hypothesis for correlating the phenomena presented by the rock-making silicates. It seems necessary therefore to keep an open mind at present as to whether the further development of silicate chemistry can best be conducted by aid of the hypotheses of the metallographer or by those of the organic chemist.

In studying the matter from the point of view of volume we are on surer ground and can keep close to facts of observation and experiment, while the new facts and relationships which emerge can be effectively applied to the elucidation of magmatic phenomena.

In Table II. the volume relationships of the principal titanium minerals, other than those of the various forms of TiO_2 itself, are presented. It will be seen that the S.V.S. of TiO_2 in a pure ferrous oxide, ilmenite, or in perofskite, is practically identical with that of SiO_2 in lime pyroxene. Pseudobrookite illustrates the effects of oxidizing ferrous to ferric oxide. Three parts FeO can combine with three parts TiO_2, but if the iron becomes oxidized 4 FeO is required to form 2 Fe_2O_3, and this can only take up 3 parts TiO_2 as against 4 in the ferrous state. The additional molecule of TiO_2, acid anhydride, would thus be liberated when its volume would necessarily be increased. Giekielite, the magnesian titanate, is never found entirely free from FeO and Fe_2O_3, but comparison with the corresponding silicates indicates that if it were, the S.V.S. of the TiO_2 would be much the same as that found in ferrous and lime titanites. Thus there is no difficulty in understanding how it comes about that the titanates can be built in to complex pyroxenes as is often the case and oxidation of ferrous iron in a titaniferous pyroxene is liable to cause complete disruption of the pyroxene crystals by the changes in the equilibrium conditions and the accompanying expansions. Disruption by water vapour in this way regenerates the "acid salt," from the crystals. It will be shown later that this oxidation of iron has much the same effect on a ferrous silicate, diminishing as it does the compressive power of the iron on silica, so that a ferruginous pyroxene whether it contain titanium or not is liable to disruption by oxidation of ferrous iron. Gautier showed experimentally that hot ferrous silicate readily becomes oxidized in the presence of water vapour with the evolution of hydrogen gas, and there is no reason for believing that ferrous titanate would not

TABLE VI. OLIVINE AND PHENACITE GROUPS. 2 RO, SiO_2.

Mineral	Chemical Composition. a = Formula weight			Sp. G. of Mineral	S.V.S. of Mineral	Sp. G. of SiO_2	S.V.S. of SiO_2	Remarks
Willemite (a)	2 ZnO 162		SiO_2	3·9 4·15	57 53	2·13 2·50	28·2 24·2	
Phenacite (a)	2 BeO 50	— –	SiO_2 60	2·95	37	2·97	20·2	
Trimerite	2 BeO	2 MnO	2 SiO_2	3·47	90·5	2·63	22·8	Approx. equal Vols. base and acid.
Forsterite (a)	2 MgO 80	—	SiO_2 60	3·2	43·7	2·78	21·5	
Monticellite (a)	MgO 40	CaO 56	SiO_2 60	3·1	50·3	2·63	22·8	
Tephroite (a)	2 MnO 142	—	SiO_2 60	3·9 4·2	52 49	2·50 2·75	24·0 21·0	Mean Sp. Gr. S.V.S.s same as Monticellite.
Knebelite (a)	MnO 71	FeO 72	SiO_2 60	3·9 4·15	52 49	2·55 2·90	23·5 20·5	
Fayalite (a)	2 FeO 144	—	SiO_2 60	3·9	52	2·61	23·0	
Olivine (1)	FeO 5·01%	MgO 51·64	SiO_2 42·3 %	3·26	—	2·77	21·6	Numbers refer to Analyses in Dana's Mineralogy, 6th Edition.
Olivine (8)	FeO 9·19%	MgO 50·13%	SiO_2 39·73%	3·35	—	2·78	21·5	
Olivine (26)	FeO 17·45%	MgO 44·06%	SiO_2 39·21%	3·48	—	3·02	19·8	
Olivine (29)	FeO 24·83%	MgO 37·62%	SiO_2 38·47%	3·42 3·50		2·78 2·83	21·6 20·5	

behave in an essentially similar manner, but on the contrary the reaction is a highly probable one having regard to the general instability of ferrous compounds in the presence of a substance, such as water vapour, which is capable of supplying the oxygen. These reactions and their accompanying volume changes are of great importance in the general theory of magmatic differentiation, and find particular application in connection with the vexed problem of the origin of the anorthosites and the enormous deposits of titaniferous iron ore that sometimes accompany this type of rock, as for instance at Iron Mountain in Wyoming and in the Adirondack region, New York. They are also of impoftance in connection with the genesis of the vast deposits of metallic copper of the Lake Superior district, one of the largest and most important group of copper deposits in the world, and probably, though in a less direct manner, the great gold deposits of the Rand, not to mention many other important ore deposits.

A few of the commoner phosphates are given in Table III. They call for no special comment other than those given in the column of remarks except to point out that combination is accompanied by considerable compression and this usually implies pronounced heat evolution. The early separation of phosphates thus provides a little heat to the main magma and may be regarded as in the nature of an annulment.

Among the spinels (Table IV.) chromite provides another instance of the "cat and dog" type of mineral constitution, for the sum of the volumes of the free oxides is considerably less than the S.V.S. of the mineral itself. In this case it is ferrous oxide pulling at the Cr_2O_3 in the endeavour to form Fe_2O_3, and it seems pretty safe to infer that the consolidation of chromite in an ore deposit is accompanied by expansion, also that in playing the chemical affinities off against one another in this way the passage from the fluid to the solid state is postponed or prolonged so that the rate of loss of energy of the system is reduced. It is noteworthy that hercynite shows a somewhat similar state of affairs though to a lesser degree. Since FeO and Al_2O_3 are often bonded together into complex ferro-magnesian silicates, this density relationship is of wider interest.

The garnet group (Table V.) is remarkable

TABLE VII. PYROXENES. RO, SiO_2.

Mineral	Chemical Composition (a) Formula wt. of Oxide (b) S.V.S. of Oxide		Sp. G. of Mineral	S V.S. of Mineral	Sp. G. of SiO_2	S.V.S. of SiO_2	Remarks
Enstatite (a) (b)	MgO 40 11·1	—	3·1 3·2	32·3 31·2	2·83 2·97	21·2 20·1	—
Hypersthene (a) (b)	3 MgO 120 33·3	FeO 72 14·5	3·35	129	2·96	20·2	129 ÷ 4 (RO) = 32·25 S.V.S. same as for Enstatite
Hypersthene (a) (b)	2 MgO 80 22·2	FeO 72 14·5	3·4 3·45	98 96·5	2·93 3·01	20·5 19·9	98 ÷ 3 (RO) = 32·7
Wollastonite (a) (b)	CaO 56 16·4	—	2·8 2·9	41·5 40	2·38 2·54	25.1 23·6	H_2O often present in Mineral
Diopside (a) (b)	MgO 40 11·1	CaO 56 16·4	3·2 3·3	68 65·5	2·97 3·16	20·2 19·0	65·5 ÷ 2 (RO) = 32·7
Hedenbergite (a) (b)	CaO 55 16·4	FeO 72 14·5	3·5 3·6	71 69	3·0 3·16	20 19	—
Lime Pyroxene (a) (b)	CaO 56 16·4	—	3·4	34·3	3·35	17·9	Deduced from Diopside
Iron Pyroxene (a) (b)	FeO 72 14·5	—	3·95 3·80	33·4 35·6	3·13 2·85	18·9 21·1	Deduced from Hypersthene and Enstatite
Rhodonite (a) (b)	MnO 71 14	—	3·65	36·0	2·73	22·0	—

for its high degree of silica compression. To find a parallel we have to go, not to the common igneous "heavy silicates," but to minerals that are typically metamorphic minerals or those that are formed from previously consolidated igneous minerals by pneumatolytic processes, such as topaz. Epidote, vesuvianite, staurolite, zoisite, etc. (see Tables IX. and X.) show the same phenomenon. Now the dense form of silica, quartz, is in a general sense the form in which it exists in sediments before they are metamorphosed.

Density analysis indicates that even in clays the SiO_2 has the volume proper to quartz. The high temperature forms of free silica are its expanded varieties, tridymite, cristobalite, etc. It seems possible to account for the high densities of the garnets and these metamorphic minerals on the hypothesis that the basic oxides operate on the denser forms of SiO_2 in the course of the metamorphic processes as against the lighter in magmas. It may also be ascribed to the nascent production of the dense form of basic oxides from the hydrates during thermo-metamorphism. It may be doubted whether garnets are formed in rock magmas that have not assimilated rocks containing hydrate oxides, though the evidence for this view is admittedly inconclusive.

Uvarovite, the chrome garnet, shows the same kind of divergence from type in the garnet group as chromite does in the spinel group.

The olivine and phenacite groups (Table VI.) do not call for much comment. Analyses 1, 8, and 29 bring out very clearly how varying the proportions of MgO and FeO, two bases of widely differing specific gravities, when allowed for by the method of density comparision here adopted, shows the S.V.S. of the silica to be practically constant, also that in an ordinary complex olivine the S.V.S. of the SiO_2 agrees pretty closely with that of the SiO_2 in the commoner varieties of complex pyroxene, such as augite. The point is of interest in connection with the resorption of olivine, since it would seem that this can be effected without any serious volume change in the SiO_2.

The non-aluminous pyroxenes (Table VII.) are on the whole appreciably denser than ordinary aluminous augites (Table X.) Compare note on hercynite. It will be seen that wollastonite, the so-called lime pyroxene, falls well outside the prevailing tenor of the series in regard to its density, whereas the density of true lime pyroxene, as deduced from diopside on the assumption that diopside is simply a physical mixture of lime and magnesia sili-

TABLE VIII. PYROXENES AND AMPHIBOLES.

Mineral	Chemical Composition (a) Formula wts. of Oxides (b) S.V.S. of Basic Oxides				Sp. G. of Mineral	S.V.S. of Mineral	Sp. G. of SiO_2	S.V.S. of SiO_2	Remarks
Jadeite (a) (Pyroxene β) (b)	Na_2O 62 22·1	Al_2O_3 102 25·5	—	4 SiO_2 240	3·34	121	3·26	18·4	Vol. of SiO_2 : Vol. of bases as 3 : 2 (approximately).
Acmite or Aegirine (a) (b) (Pyroxene β)	Na_2O 62 22·1 Li_2O	Fe_2O_3 160 30·5	—	4 SiO_2 240	3·53 3·63	131 127	3·06 3·23	19·6 18·6	Sp. G. of Mineral usually approximates 3·53. Vol. of SiO_2 : Vol. of bases as 3 : 2 (approx).
Spodumene (a) (b)	Li_2O 30 14·2	Al_2O_3 102 25·5		4 SiO_2 240	3·17	117	3·10	19·3	
Pyroxene γ (Hypothetical) (a) (b)	MgO 40 11·1	Al_2O_3 103 25·5	—	SiO_2 60	3·60 3·30	56 61	3.1 2·46	19·4 24·5	Attempted approximations deduced from Augite. Compare Kornuperine.
Anthophyllite (a) (b)	3 MgO 120 33·3	FeO 72 14·5	—	4 SiO_2 240	3·1	140	2·6	23	140÷4=35. (Compare Grünerite).
Tremolite (a) (b)	3 MgO 120 33·3	CaO 56 16·4		4 SiO_2 240	2·9 3·1	143 134	2·57 2·84	23·3 21·1	Mean S.V.S. 1 RO. SiO_2 =34·6
Actinolite (a) (b)	11 MgO 440 122·1	4 CaO 224 65·6	1 FeO 72 14 5	16 SiO_2 960	3·0	—	2·66	22·6	———
Glaucophane (a) (b)	2 FeO 144 29	4 MgO 160 44·4	3 Na_2O 186 66·6	3 Al_2O_3 306 76·3	3·1	605	2·8	21·5	18 SiO_2 to complete formula.
Grünerite (a) (b)	—	—	FeO 72 14·5	SiO_2 60	3·7	35·5	2·86	21·0	Compare Iron Pyroxene.
Magnesia Amphibole (a) (b)	—	—	MgO 40 11·1	SiO_2 60	2·88	34·8	2·53	23·7	Compare Enstatite. Deduced from Grünerite and Anthophyllite.
Lime Amphibole (a) (b)	—	CaO 56 16·4	—	SiO_2 60	3·94 3·47	29·5 38·5	4·6 2·7	13·1 22·1	Compare Wollastonite and Lime Proxene. For Mean S.V.S. of 35. S.V.S. of SiO_2 = 19·6

cates, is inclined to be higher than that of magnesia and ferrous pyroxene. This high density of true lime pyroxene is what we may reasonably expect from the exceptionally high expansion that takes place when anhydride lime passes over to the hydrate form and the very pronounced heat evolution which accompanies it, since in the anhydride form the potential energy of the system must be correspondingly increased. Wollastonite is, however, typically a metamorphic mineral and is formed from more or less hydrated lime. It is perhaps worth noting that if we suppose that the expansion of lime or the reverse process may take place possibly in two approximately equal stages, wollastonite would then work out at approximately equal volumes of lime and SiO_2 and the SiO_2 density would be on all fours with the other pyroxenes.

There are other lime minerals that suggest that this may be the case. It may be as well to recall that lime has not been investigated as Ditte investigated magnesia, but that it was a single highly expanded form that was discovered without the intermediate gaps being filled in.

The alkali pyroxenes, jadeite, acmite, etc., are somewhat denser than the non-alkaline varieties, which is doubtless connected with the greater "basicity" or compressive power of anhydride soda. It should be borne in mind that the soluble bases soda and potash are able to "fix" a larger quantity of SiO than the insolubles.

The amphiboles as a group present a very similar picture to the pyroxenes, but the SiO_2 approximates in S.V.S. to that of quartz, whereas in the previous groups it is markedly less than that of quartz. The amphibole group is one in which it is not at all improbable that both hydrate and anhydride forms are both co-existent, so that the S.V.S. figures for SiO_2 calculated on the basis of anhydride forms only is only useful in the sense of using the SiO_2 as a sort of common denominator for the comparison of mineral densities. There is, however,

TABLE IX. FELSPARS, FELSPATHOIDS, ETC.

Mineral		Chemical Composition (a) Formula wts. of Oxides (b) S.V.S. of Oxides				Sp. G. of Mineral	S.V.S. of Mineral	Sp. G. of SiO_2	S.V.S. of SiO_2	Remarks
Orthoclase	(a) (b)	K_2O 94 40·5	Al_2O_3 102 27·3	—	6 SiO_2 360 146·2	2·60	214	2·46	24·4	Microcline, Sp. G. a trifle less (2·58)
Albite	(a) (b)	Na_2O 62 27·3	Al_2O_3 102 27·3	—	6 SiO_2 360 145·4	2·63	200	2·48	24·2	
Anorthite	(a) (b)	CaO 56 23·4	Al_2O_3 102 27·3	—	2 SiO_2 120 49·3	2·76	100	2·43	24·6	Approx. equal vols. of basic oxides and SiO_2
Beryl	(a) (b)	3 BeO 75·3 25·2	Al_2O_3 102 27·3	—	6 SiO_2 360 146·5	2·70	199	2·45	24·4	Sp. G. varies from 2·62—2·8, usually 2·7
Nephelite	(a) (b)	Na_2O 62 27·3	Al_2O_3 102 27·3	—	2 SiO_2 120	2·55 2·65	112 107	2·12 2·32	28·4 26·0	107 = 214 (orthoclase) ÷ 2 Compare S.V.S. relationship between Albite and Anorthite. Approx. equal vols. acid and base
Nephelite	(a) (b)	3 Na_2O 186 81·9	K_2O 94 40·5	4 Al_2O_3 408 109·2	9 SiO_2 540 242·4	2·60	474	2·24	26·9	
Kaliophilite	(a) (b)	K_2O 94 40·5	Al_2O_3 102 27·3	—	2 SiO_2 120 —	2·6 2·5	121 126	2·25 2·06	26·6 29·1	
Leucite	a) (b)	K_2O 94 40·5	Al_2O_3 102 27·3	—	4 SiO_2 240 118·2	2·48	176	2·03	29·5	
Eucryptite	(a) (b)	Li_2O 30 14·2	Al_2O_3 102 27·3	—	2 SiO_2 120 —	2·67	95	2·25	26·7	
Scapolite (Meionite)	(a) (b)	4 CaO 224 93·6	3 Al_2O_3 306 81·9	—	6 SiO_2 360 —	2·74	325	2·43	24·6	S.V.S. Meionite : S.V.S. Marialite as S.V.S Anorthite : S.V.S. Albite Approx. 2 vols. SiO_2 to 1 vol. base also as S.V.S. orthoclase : S.V.S. nephelite
Scapolite (Marialite)	(a) (b)	3 Na_2O 186 81·9	3 Al_2O_3 306 81·9	2 $NaCl$ 117 54	18 SiO_2 1080 —	2·56	660	2·43	24·6	
Sodalite	(a) (b)	3Na_2O 186 81·9	3 Al_2O_3 306 81·9	2 $NaCl$ 117 54	6 SiO_2 360 —	2·2 2·3	440 422	1·66 1·77	37·0 34·0	Approx. equal vols. bases, including NaCl and Acid (SiO_2)
Noselite	(a) (b)	2 Na_2O 124 54·6	3 Al_2O_3 204 54·6	Na_2SO_4 142 54·6	4 SiO_2 240 —	2·3 2·4	296 284	1·82 2·0	33·0 30·0	

a possible alternative explanation, namely, that the amphiboles are related to the pyroxenes in much the same way as marcasite is related to pyrite.

A very remarkable feature of so many of these complex minerals is the frequency of the occurrence of equal volumes of base and SiO_2 in the architecture of the systems. It rather suggests that equalization of volumes tends toward maximum stability. The general idea of the approximation of volumes seems to run through the whole magmatic differentiation scheme, for at one end of the series of minerals the small volumed bases correspond with small volumed SiO_2 and the large volumed bases correspond with large volumed SiO_2. The S.V.S. of the SiO_2 and consequently the over-all density, is also clearly to some extent dependent on the relative proportion of SiO_2 to the sum of the bases in complex minerals. If the proportion of SiO_2 is diminished we have a relatively larger proportion of bases operating on the SiO_2 and, other things being equal, the SiO_2 is more compressed. Many of the variations in density among different specimens of the same species can be explained in this way, as will be apparent from a perusal of the tables.

The felspar group is characterized by a SiO_2 volume closely approximating that of cristobalite. It is worthy of remark how the densities of this group when evaluated in terms of the hydrolysed oxides give such a uniform value for the silica volume, although the allotropic changes of volume of the bases vary so widely, and anorthite differs so markedly in

TABLE IX. CONTINUED FROM OPPOSITE PAGE.

Haüynite		2 CaO	Al_2O_3	Na_2SO_4	2 SiO_2	2·45	456	1·88	32·0	Noselite with 1 Na_2O replaced by CaO + Lime—Soda Sulphosilicate
	(a)	112	102	142	120					
	(b)	46·8	27·3	54·6						
		Na_2O	2 Al_2O_3	Na_2SO_4	4 SiO_2					
	(a)	62	204	142	240					
	(b)	27·3	54·6	54·6						
Cancrinite		2 Na_2O	2 Al_2O_3	Na_2CO_3	6 SiO_2					
	(a)	124	204	106	360	2·4	580	1·89	31·7	H_2O and Na_2Co_3, and acid SiO_2
	(b)	54·6	54·6	40·2						
		CaO	2 Al_2O_3	Na_2CO_3	3 SiO_2					
	(a)	56	204	106	180	2·5	580	2·02	29·4	Approx. equal vols. bases, including S.V.S. approx.: twice S.V.S. of Noselite
	(b)	23·4	54·6	40·2						
					+3 H_2O					
	(a)	—	—	—	54					
	(b)	—	—	—	27					
Muscovite		K_2O	3 Al_2O_3	2 H_2O	6 SiO_2					
	(a)	94	306	36	360	2·85	280	2·56	23·0	Equal vols. acid and base. H_2O = base
	(b)	40·5	81·9	18						
Paragonite		Na_2O	3 Al_2O_3	2 H_2C	6 SiO_2					Sp. G. varies from 2·74-2·90
	(a)	62	306	36	360	2·80	272	2·48	24·2	
	(b)	27·3	81·9	18						
Chloritoid		FeO	Al_2O_3	H_2O	SiO_2	3·5	72	2·84	21·2	High proportion of base to SiO_2: considerable compression of SiO_2
	(a)	72	102	18	60	3·6	70	3·12	19·2	
	(b)	14·5	27·3	9						
Zoisite		4 CaO	3 Al_2O_3	H_2O	6 SiO_2					S.V.S. same as white micas CaO considered as non-hydrated
	(a)	224	306	18	360	3·35	272	3·13	19·2	
	(b)	49·2	81·9	9						
Topaz		2 AlF_3	3 Al_2O_3		4 SiO_2					S.V.S. practically the same as Albite
	(a)	168	306	—	240	3·5	204	3·5	17·0	
	(b)	54·4	81·9							
Kornuperine		MgO	Al_2O_3		SiO_2	3·33	62·3	2·33	25·7	Probably not identical with Aluminous Pyroxene, but oxides in hydrate form either entirely or partially
	(a)	40	102	—	60	3·34	60·7	2·47	24·1	
	(b)	11·1	25·5							
Cordierite		2 MgO	2 Al_2O_3		5 SiO_2	2·60	225	2·05	29·1	Compare with Leucite
	(a)	80	204	—	300	2·66	220	2·13	28·1	
	(b)	25	54·6							
Sapphirine		5 MgO	6 Al_2O_3		2 SiO_2					Indicating that a large mass of basic oxides in hydrate form can compress a small amount of SiO_2
	(a)	200	612	—	120	3·48	268	2·80	21·5	
	(b)	62·5	163·8							
Andalusite		—	Al_2O_3		SiO_2					Hydrate alumina
	(a)	—	102	—	60	3·16	51·2	2·50	24·0	
	(b)	—	27·3		—					
Kyanite		—	Al_2O_3		SiO_2	3·56	45·6	2·98	20·2	Anhydride alumina.
	(b)	—	25·5	—	—	3·67	44·2	3·22	18·7	S.V.S. of SiO_2 as in pyroxenes
Sillimanite (Fibrolite)	(b)	—	Al_2O_3 25·5	—	SiO_2 —	4·23	50·1	2·44	24·5	Anhydride alumina. Approx. equal vols. SiO_2 and Al_2O_3 S.V.S. SiO_2 approximates Tridymite

its SiO_2 ratio from the other two. It will be noted that beryl fits in the felspar series and its over-all S.V.S. is identical with that of albite, while the volume of 3 BeO lies in between Na_2O and CaO. The fact that 3 molecules of BeO are present as against the single molecules in the other minerals is another striking testimony to the important part played by volume relationships in the construction of the felspar group. The S.V.S. of albite appears as twice that of anorthite and not equal to anorthite as is commonly stated. The two end terms of the scapolite series, meionite and marialite, stand to one another in much the same kind of relationship as regards their over-all S.V.S., while the SiO_2 S.V.S. is approximately equal to that in the felspars.

The felspathoids are characterized by extreme expansion of SiO_2, and recall the phenomena presented by chalcopyrite among the sulphides. It seems possible that the basic chemical affinities are played off against one another to some extent in these minerals, though there does not appear to be any convincing way of demonstrating this. Nevertheless Thugutt has shown by his experimental investigations of nephelite that different portions of the soda behave in different ways to chemical reagents. It is interesting to note that cordierite is an expanded mineral comparable with the felspathoids in this respect.

The micas fall into a transitional series, with muscovite approaching the amphiboles, biotite and paragonite the felspar, or between them and the felspathoids, while lepidomelane leans strongly toward the felspathoids, as re-

TABLE X.

Mineral	Chemical Composition. (a) % of oxide in mineral. (b) Space occupied = % ÷ Sp. Gr. of oxide.									Total vol. of bases	Sp. Gr. (a) 100 ÷ Sp. Gr. (b)	Sp. G. of SiO_2	S.V.S. of SiO_2	Remarks
	MgO	FeO	CaO	Na_2O	Al_2O_3	Fe_2O_3	K_2O	H_2O	SiO_2					
Augite (a) (b)	3·56 0·96	8·54 1·70	10·40 3·05	10·69 3·80	5·17 1·28	16·86 3·20	2·64 1·03	—	42·15 14·98	15·02	3·35 30·00	2.8	21·5	Equal vols. bases and SiO_2. Analysis 74 Dana.
Augite (a) (b)	10·13 2·80	15·94 3·20	21·14 6·18	—	1·31 0·33	—	—	—	51·46 18·19	12·51	3·27 30·7	2·8	21·5	Analysis 57 Dana.
Augite (a) (b)	7·50 2·07	— —	22·67 6·60	— —	15·39 3 85	11·32 2·16	— —	— —	42·50 14·62	14·68	3·42 29·30	3·73	22·0	Equal vols. bases and SiO_2. Analysis 74 Dana.
Augite (a) (b)	14·42 4·00	9·82 1·98	21·86 6·40	— —	4·16 1·04	—	—	—	49·60 16·58	13·42	3·32 30·00	2·97	20·1	Analysis 69 Dana.
Chrome Diopside (a) (b)	17·84 4·93	5·03 1·01	17·39 5·08		7 42 1·86	Cr_2O_3 2·61 0·52	—	—	49·71 17·10	13·40	3·28 30·50	2·90	20·6	Analysis 40 Dana.
Hornblende (Pargasite) (a) (b)	9·10 2·52	19·02 3·80	10·73 3·15	1·79 0·38	14·28 3·60	2·56 0·49	2·85 1·06	—	39·80 15·50	15·00	3·30 30·50	2·55	23·5	Equal vols. bases and SiO_2. Aualysis 111 Dana.
Amphibole (Nephrite) (a) (b)	23·40 6·50	3·46 0·70	11·50 3·38	—	1·54 0·37	—	—	3·14 1·57	56·88 21·48	12·52	2·93 34·00	2·64	22·7	Calculated from Anhydride forms of oxides.
Muscovite (a) (b)	1·56 0·39	1·69 0·34	0·23 0·10	0·54 0·20	30·86 8·10	5·70 1·08	9·07 4·00	4·60 2·30	45·87 17·09	16·51	2·89 34·60	2·66	22·5	Calculated from hydrate forms of oxides. Approx. equal vols. acid and base.
Biotite (a) (b)	21·08 6·60	5·92 1·19	— —	1·55 0·68	16·47 4·31	2·16 0·41	9·01 3·92	2·19 1·10	40·81 17·08	18·22	2·85 35·1	2·37	25·20	Analysis No. 2 Dana hydrate forms of oxides. Approx. equal vols. acid and base.
Biotite (a) (b)	26·15 8·20	4·12 0·86	— —	0·37 0·16	15·79 4·22	2·53 0·48	7·64 3·38	3·58 1·79	40·16 17·20	19·09	2·75 36·5	2·34	25·60	
Biotite (a) (b)	16·34 5·10	14·75 2·96	— —	0·53 0·23	14·43 3·90	5·44 1·04	8·12 3·48	0·90 0·45	38·49 15·10	18·16	3·00 33·3	2·50	24·0	FeO raises Sp. G. of SiO_2.
Lepidomelane a b	0·26 0·08	12·43 2·50	— —	— —	11·60 3·12	27·66 5·24	9·20 3·95	0·60 0·30	37·40 18·10	15·2	3·00 33·3	2·05	29·3	Fe_2O_3 has opposite effect to FeO on SiO_2.
Lepidomelane a b	6·87 2·14	17·40 3·50	1·66 0·69	—	14·40 3·85	14·70 3·16	5·54 2·38	0·90 0·45	36·43 16·50	16·2	3·07 32·4	2·19	27·3	Equal vols. acid and base. SiO_2 intermediate Sp.G. with less Fe_2O_3.
Epidote (a) (b)	—	0·48 0·05	23·47 6·82		23·43 6·2	18·31 2·52	—	2·06 1·03	37·83 12·20	16·6	3·466 28·8	3·10	19·4	Al_2O_3 hydrated but CaO as anhydride.
Axinite (a) (b)	—	1·60 0·32	18·25 5·30	MnO 13·69 2·68	16·73 4·15	1·03 0·20	B_2O_3 5·10 2·08	—	42·77 14·87	14·73	3·36 29·6	2·86	21·0	Equal vols. SiO_2 and other oxides.
Cordierite (Iolite (a) (b)	7·81 2·16	8·55 1·72	0·46 0·19	1·32 0·26	32·36 8·50	—	—	1·55 0·77	48·43 24·40	13·60	2·64 38·0	2·00	30·0	Hydrate forms throughout.
Vesuvianite (a) (b)	2·70 0·73	1·23 0·24	36·01 10·05	1·86 0·50	16·31 4·29	3·85 0·73	0·23 0·09	3·40 1·70	36·29 11·10	18·30	3·4 29·4	3·25	18·4	Al_2O_3 hydrated. CaO as anhydride.
Staurolite (a) (b)	3·28 0·91	7·80 1·56	—	—	52·92 13·80	6·87 1·3	—	1·59 0·8	27·91 8·4	18·4	3·71 26·8	3·30	18·2	Al_2O_3 considered as hydrated.
Tourmaline (a) (b)	9·51 2·64	4·42 0·88	1·25 0·36	2·00 0·70	34·26 9·0	B_2O_3 7·82 3·20	0.43 0·17	2·61 1·30	32·7 14·45	18·52	3·07 32·7	2·60	23·2	B_2O_3 assumed to have S.V.S. as in $Na_2B_4O_7$
Tourmaline Ferruginous) (a) (b	0·78 0·24	17·40 3·50	0·72 0·30	1·36 0·48	30·34 8·00	B_2O_3 11·11 4·55	0·58 0·23	1·54 0·80	36·06 12·40	18·5	3·243 30·9	2·94	20·5	F. 85% S.V.S. =· 4 approx.
Melilite a) (b)	6·44 1·77	—	32·47 9·40	1·95 4·69	6·42 1·63	10·17 1·92	1·46 0·57	—	39·27 17·7	16·0	2·95 33·7	2·22	27·0	Anhydride forms of oxides used in computation.

gards their comparative densities. It is interesting to note that muscovite and biotite on fusion and re-solidification break down into felspathoidal materials such as leucite, nephelite, etc.; also that garnets yield a proportion of expanded silicates. An endeavour has been made to present the relationships of the three forms of aluminium silicate, andalusite, kyanite, and sillimanite, in accordance with their modes of occurrence in rocks. Table X. has been computed on slightly different lines from the other tables to meet the case of complex silicate minerals where it is not practicable to assign definite chemical formulae based on the analyses.

(*To be continued*).

NEWS LETTERS.

TORONTO.

May 3.

EXPANSION OF NICKEL REFINING.—The industry of nickel refining, for which two plants are now under construction, will be on a considerably more extensive scale than was at first projected. A merger has been arranged between the International Nickel Co. of Canada and the Canadian Copper Co., both subsidiaries of the International Nickel Co., of New Jersey, with a capitalization of $50,000,000. The Canadian Copper Co. operates the International Company's mines at Sudbury, shipping the output in the form of matte to be refined in the United States. The International Nickel Co. of Canada was incorporated in 1916 to comply with a demand of the Government that nickel matte be refined in Canada in sufficient quantity to meet the requirements of the British Empire, and is capitalized at $5,000,000. It has a refinery under construction at Port Colborne, Ontario. The increased capitalization, according to the officials of the Ontario Department of Mines, indicates the intention of the International Co. to transfer to the Canadian plant a large portion and perhaps ultimately the whole of the refining operations now carried on at Bayonne, New Jersey. As the Port Colborne refinery is being constructed on the unit system it can be gradually extended as required. The reason for this step is that in addition to the heavy taxation levied upon its output by the Ontario Government it is also liable to American war taxes, which may possibly be largely increased. The transfer of its operations to Canada will enable the company to avoid the double impost.

SUBSTITUTE FOR ANTHRACITE.—A proposal which has for some time been under consideration as a partial solution of the fuel problem as affecting the prairie provinces, has at length taken practical shape. The Canadian Government, acting in conjunction with the Governments of Saskatchewan and Manitoba, has decided to establish in Saskatchewan a plant for converting the lignite coal of that province into briquette fuel. It is claimed that experiments have proved that two tons of lignite can be converted into one ton of briquettes approximating anthracite in heating value, in addition to valuable by-products. The plant will cost $400,000, half of which will be contributed by the Dominion and the remainder by the Provinces interested.

PORCUPINE.—The high cost of labour and materials is considerably curtailing the output of the Porcupine mines. The larger producing mines are competing in the labour market, and others find it unprofitable to give the high wages demanded, preferring to limit production. The Hollinger is pursuing a conservative policy as regards dividends, and is maintaining production with a staff of 1,400 men, operating its mill to about three-quarters capacity. The Dome has not resumed milling operations. The shaft has been sunk to the 1,300 ft. level and will be continued to 1,500 ft. The McIntyre management, which was planning the installation of extensive additional equipment, has for the present abandoned its policy of expansion until conditions are more favourable. The mill is treating an average amount of 500 tons of ore daily, with a recovery of about $10 per ton. The shareholders of the Newray have ratified an agreement to give the McIntyre an option on 1,530,000 shares of the stock at 45c. per share. The Porcupine Crown has largely reduced its staff. The annual report of the Dome Lake shows a recovery of $45,029 from the treatment of 16,388 tons of ore at a cost of $133,5076, leaving a deficit of $88,478. The vein on the Thompson-Krist property, which is being developed at the 400 ft. level from the Vipond-North Thompson adjoining, has widened to 4 ft. and is stated to carry $10 to the ton.

KIRKLAND LAKE. — The Lake Shore has made its first shipment of gold bullion amounting to $40,000, the result of 23 days' run of the mill. The ore treated averaged about $28 to the ton. The output of the Teck Hughes for March showed a falling off, the value of the gross output being $11,538 from the treatment of 1,969 tons of ore of an average grade of $5·86. The output in February was $17,538. The Kirkland Lake mine has the deepest shaft in the district, being down 700 ft. The vein has been driven on for 100 ft. and is about 8 ft. wide of high grade. At the Elliott-Kirkland high-grade ore has been proved at the 420 ft. level. The shaft is down 480 ft. A new vein 6 ft. wide carrying free gold has been encountered on the 125 ft. level of the Burnside. Work is to be resumed on the Ontario Kirkland, formerly known as the Hurd claims. This property was formerly under option to the La Rose of Cobalt, which put a shaft down to the 100 ft. level. Favourable developments on adjoining properties have induced the resumption of operations.

COBALT.—The silver mining industry has received a great stimulus from the fixing of the price of silver in the United States at $1·00 per oz. and operations are being resumed on properties that had been closed down for some time. The annual statement of the Nipissing shows production of 4,212,247 oz. of silver of the gross value of $3,756,889. Cost of production was $1,057,987, leaving a profit of $2,698,902. No large veins of importance were found. Reserves had decreased by about 600,000 oz. and were estimated at 8,076,540 oz. The McKinley-Darragh has decided to make a thorough exploration of the Savage property, of which there are from eight to twelve acres of conglomerate area as yet unexplored. The Temiskaming is carrying on exploration work at the 1,600 ft. level below the diabase sill and driving on a vein found some time since. Promising discoveries have been made on the Green Meehan, Three Star, and Genessee properties. The Mining Corporation of Canada is increasing its mill capacity to allow of the treating of 300 tons of tailing daily, which has accumulated in Cobalt Lake, and will gradually increase this to 700 tons. The production of Kerr Lake is maintained, the output for March being 207,100 oz. The oil flotation plant at the National (formerly the King Edward) has resumed operations with satisfactory results.

MELBOURNE.

March 12.

LABOUR AT PORT PIRIE.—With a view to encourage regular attendance, and at the same time enable every employee and his family to take an annual holiday, the Broken Hill Associated Smelters, operating the lead and zinc smelters at Port Pirie, has decided to grant an attendance bonus to all employees not at present enjoying holiday leave on pay. Great difficulty has been experienced in arriving at a fair basis for this attendance bonus, as so many men during the war period have been brought to Port Pirie, worked a short intermittent period, and then left. It has therefore been decided to have a test period of six months, from March to September of this year. All employees who comply with the standard and conditions set out in the attached rules will be entitled to a week's leave on full pay, not including overtime. For instance, shift men receiving 11s. per day will be entitled to receive £4. 2s. 6d. on the eve of leaving for a week's holiday. The intention of the company is to grant for the twelve months following September, 1918, an attendance bonus of a fortnight on full pay to all employees who comply with the standard fixed. When the experience of the first six months is available, the conditions will be arranged so that the attendance bonus will be on a graduated scale. Those who have failed to reach the full standard will get proportionately reduced leave on pay. Also, those who have been in the company's employment for between six and twelve months will be granted leave on a proportional basis.

On the actual figures for the year 1917, the bonus offered for the first six months, March to September, 1918, is within the reach of all employees in the works. Absence from work through accident or sickness will not be counted against the employees, provided that they produce medical certificates. Arrangements have been made under which the company's doctor will supply certificates, where necessary, to employees free of charge. This attendance bonus does not alter any of the existing conditions of work or rates of pay in the smelters, but is an additional payment for regular attendance. Preparations are being made to establish a holiday camp at a beach on the other side of Spencer Gulf. Employees will be quite free to take their holidays where they please, but they will have the right to bring their families to the holiday camp during the period of their holiday leave. In this way it is hoped to provide facilities for every employee and his family to get a healthy, enjoyable holiday once a year at a cost that will not amount to more than their ordinary living expenses. These preparations may be delayed, for the scarcity of labour and lack of shipping facilities are making it difficult to provide a pier and other equipment necessary.

BULAWAYO.

March 27.

Mining Conference. — The chief interest in Rhodesian mining circles during the past few weeks has centred round the Second Mining Conference held in Bulawayo on March 20 and 21, and presided over by Sir Bourchier Wrey, President of the Rhodesian Chamber of Mines. It was well attended, and the Secretary for Mines, Mr. E. W. S. Montagu, was present at all the discussions, taking part in many of them. Most of the matters dealt with were of more local than general interest. Some indeed were put off to a future date in order to give time for the formation of a mine managers' association to which they might be referred. The state of the roads, as was scarcely surprising in view of the very heavy rainy season we have been experiencing, came in for considerable attention, and feeling at the Government's *non possumus* on the subject led to the Chairman's having to pull up more than one speaker for trenching on politics. Perhaps the subject of greatest general interest was the encouragement of prospecting, on which two motions were tabled, the more important of which was brought forward by the Small Workers' Association. Eventually, however, both were withdrawn in favour of an amendment proposed by Mr. F. P. Mennell, which was adopted *nem. con.* The proposal is to subsidize genuine prospectors by issuing to them free mining supplies to a reasonable extent, and giving them credit notes to be honoured by storekeepers for their own and "boys" food, the total grant being limited to £15 per month. Such a sum is not likely to appeal to the man who merely wants an excuse for doing a bit of shooting during the dry season. This is considered a strong point in favour of the scheme, and also renders it practicable from the point of view of expense. It is also commended as affording help to the *bona fide* prospector without hampering his movements in any way, and leaving him to be paid by results.

Arsenic.—A new product has been added this year to our list of mineral exports, namely, white arsenic. This is a very important material in South Africa, as the systematic dipping of cattle which is practised has led to a large local demand for arsenite of soda and other arsenical compounds. The arsenic now being produced comes from the Bessie mine in the Umtali district. Its opening up is due in the first instance to that very useful body, the Rhodesian Munitions and Resources Committee, whose chairman, Mr. J. G. McDonald, has, by the way, been honoured with the new order of the British Empire. The arsenic, which is shipped to the Transvaal, has been very favourably commented on as regards its purity. The unit of plant which has so far been installed has a capacity of ten tons per month, but it has been stated that the deposit is capable of supplying the whole South African demand for arsenic. However this may be, it will undoubtedly contribute materially toward relieving the shortage of dip which is everywhere complained of.

CAMBORNE.

Grenville.—The accounts for the half-year ended December 31 last show a loss of £626, which is certainly much less than was generally anticipated. The quantity of ore milled was 19,925 tons, or a decrease of 1,085 tons on the previous six months, while the black tin production was 241 tons, or a recovery of 27·05 lb. per ton, as compared with 23 lb. per ton for the first half of the year. The reduction in the tonnage is due to a lessened labour force, while the higher recovery is an encouraging feature. Judging from the report and the manager's remarks at the meeting, there seems every likelihood that during the coming months a further substantial improvement in this direction will be seen. One of the most important development points is the 395 fm. level, west of Fortescue's shaft, where, it will be recalled, the main shoot of ore showed very disappointing values. In this same shoot, a winze was sunk from the 375 fm. in the north section of the lode, which has hitherto given the highest values, but there was no improvement. A cross-cut through the lode was then undertaken with the result that good values (56 lb. black tin per ton) were found in the south section, and the manager anticipates that the rise now being made from the bottom level to meet the winze referred to will open up a large block of good grade ore. The driving of the 395 fm. level east of Fortescue's shaft has now been resumed, after having been suspended by reason of the scarcity of rock-drill men, and this, too, is regarded by the manager as a most promising point. Some of the upper levels are being re-opened with good results, and the chairman has stated that 20 lb. ore will show a profit of about 5s. per ton at the present price of metal, with the operating cost at about 35s. per ton. But it seems doubtful if the operating cost can be kept at 35s. per ton if the mine is being worked profitably, for then high royalties become payable and local rates come into operation. The 35s. per ton operating cost includes no royalties, and as no royalties were payable, practically no local rates either were paid. Wages too have increased since the account was made up, on which the working cost referred to was obviously based. However, there is doubtless a large tonnage of ore opened up which, with labour available, could be mined fairly cheaply, and would certainly help to reduce the standing charges, but whether the necessary labour can be secured is a very doubtful matter. Indeed, any extra labour available should, and doubtless would, be used for development, which has necessarily been much neglected for some time past. If the present output can be maintained, the manager will have done well, and profits will depend on higher lode values, a maintained metal price, and no substantial increase in the operating cost. It is noticeable that the tributes are being paid on a black tin standard of £70 and £75 per ton; surely, with black tin realizing £220 per ton, the tributers, who are getting very scarce, should be encouraged with a standard somewhat nearing the price now ruling.

NON-FERROUS METAL INDUSTRY ACT, 1918.—Under this Act, which was passed by Parliament on February 6 last, it becomes necessary within six months of the passing of the Act, for every Cornish base metal mining company to secure a licence to carry on such business. The Board of Trade has issued rules governing the procedure in respect to the issue of such licences, from which it appears that they have power at any time to require directors, officials, or shareholders to furnish such information as to the company as may be demanded, and to require the production of the books to verify any such statements. The object of this legislation is, of course, to eliminate enemy influences from controlling base metal mines in this country, and in the great majority of cases the application for a licence will doubtless be purely a formality. In the case of a company, every director, manager, or secretary who is knowingly a party to any offence under the Act is liable to imprisonment and a fine. A fee of one guinea is chargeable for a licence. Applications should be made to the Board of Trade (Industries and Manufactures Department).

MINING MACHINERY DEPRECIATION.—Under the 1918 Finance Bill, power is given for the question of the rate of depreciation for a particular class of trade or business to be determined by a Board of Referees. The principle adopted in the case of Excess Profits Duty capital percentages is thus being applied to income tax. The procedure is by application to the Board of Inland Revenue, but it is a condition precedent that a considerable proportion of the companies in a particular class of trade are dissatisfied with the existing depreciation allowance, so that individual applications have little chance of being heard. In Cornwall, the depreciation allowance on machinery is 5%, but with the increasing use of electrical plant, the life of which is usually less than steam plant, and the difficulties of keeping machinery of all kinds in an efficient state at the present time, should both be good reasons for a higher percentage. The Cornish Chamber of Mines, having been so successful in its Excess Profits Duty appeal, is obviously the right organization to take this matter in hand, and it is to be hoped that the companies concerned will press the Chamber to move. In the case of some mines, East Pool for instance, the plant is presumably being run to its fullest capacity and the wear and tear is obviously greater. The memorandum recently issued by the Board of Inland Revenue on the subject of depreciation should be in the possession of every Cornish mining company.

CARNON VALLEY (CORNWALL) LTD.—There would appear to be good grounds for believing that this company will resume operations in the near future, as it is proposed to raise further working capital to the tune of £20,000 by the issue of 7½% prior lien debenture stock, ranking in priority to the existing debenture stock. The company was formed to work the alluvial tin sands at Carnon, and although a very extensive plant was erected, for some reason or other, principally, I believe, because it was erected in the wrong place, the operations were not successful. The higher price now ruling for the metal has doubtless encouraged a further effort, and certainly the assays of the ground leased by the company, which were most carefully and systematically taken, justify hopes of a highly profitable result if the work is tackled in the right way.

LABOUR.—The Workers' Union has again made application to the mines in the Camborne-Redruth area, on behalf of its members, for increased rates of pay. It was only toward the end of last year that substantial advances were made to both underground and surface workers, and the principle of the minimum wage recognized. The statements of accounts recently issued by companies working mines producing only or mainly tin, such as Dolcoath, Grenville, Basset, or Levant, show that there was no margin of profit earned which would admit of a further advance in wages, particularly when it is remembered that such accounts covered periods ended December 31 last, when the advances above referred to had only been in operation for a month or two. The companies operating mixed ores may be in a position to grant a further increase, but obviously the others cannot stand it, particularly as there has been no increase in the output per man as the result of the minimum wage. It is anticipated that the companies will decline to entertain the new application.

The Chamber of Mines at once took firm action on the threatened withdrawal of more men from the mines for military service as the result of the new Military Service Act. The Ministry of Munitions has for some time been urging the increased production of tin, wolfram, and arsenic from Cornish mines, and yet the National Service Department, on the other hand, presses for more men for army service. Already the mines—particularly those producing only tin—have been skinned of labour to such a point that great difficulty has been experienced in keeping the mines going, and indeed, as the recent published reports show, development is being seriously neglected to enable the outputs to be maintained. Is it too much to hope that there may be some co-ordination between these Departments in the future? The calling up of men is for the moment suspended, and it is to be hoped that the Chamber's protest will prove effective.

GERMAN PRISONER LABOUR.—A complete *volte face* has been made by the Army Council in the matter of the employment of prisoner labour in the mines, for an intimation has been received that prisoners are now available for both surface and underground work. The companies have to be responsible for providing accommodation for these prisoners and make arrangements for cooking; otherwise the army authorities will be responsible for the guard, for providing rations, and also for bedding, equipment, etc. The rate of pay is to be that ruling in the district for free labour. The Union men are taking strong exception to the employment of prisoners, and I have not yet heard of a case where they have been used underground.

PARK-AN-CHY.—The stoppage of work at this property in the Scorrier district belonging to the Cornish Wolfram Mines came as a surprise, for it was generally understood, and certainly the published reports led to the conclusion, that developments were perfectly satisfactory. In November last it was stated that 25,000 tons of payable ore had been developed, There has certainly been trouble with the treatment plant, but that, it was understood, would speedily be overcome. The company has evidently come to an end of its financial resources, for the wages of the employees for two weeks are outstanding, and the men were dismissed practically without notice. The Government was interested financially in this undertaking, having lent £10,000 on the security of the plant. This is the second wolfram undertaking to close down lately; operations at the Buttern Hill property having been suspended a few months since.

PERSONAL.

LT.-COL. LESLIE BROWN, D.S.O., of the Consolidated Gold Fields staff, is in London from East Africa, where he has been in charge of the mechanical transport.

W. SINCLAIR BROWN has returned from Sumatra and is now employed by the Air Board at Swansea.

T. P. E. BUTT has been appointed consulting electrical engineer to the Johannesburg Consolidated Investment Company.

CAPTAIN CALDER, of Johannesburg, a member of the Central Mining staff, has received an appointment at the Handley-Page aeroplane works, near London.

H. R. EDMANDS, lately metallurgist at Yuanmi, is installing his charcoal precipitation process at the Riverina South mine, Menzies, West Australia.

ERROL HAY has been appointed technical adviser to the Albu group.

NICHOLAS HOLMAN has been appointed manager of the Wymah wolfram mine, Albury, New South Wales.

H. F. HUESTON is home from Nigeria.

ARTHUR JARMAN, lately with the Waihi Grand Junction, is now chemist with Wilson's Portland Cement Co, Warkworth, New Zealand.

ROBERT M. KEENEY is advising the Anaconda company in connection with the metallurgical plant for making ferro-manganese.

JAMES KNIGHT, manager of the Ninghi, is home from Nigeria.

R. N. KOTZE, Government Mining Engineer for the Union of South Africa, has been created a Knight.

GERARD LOVELL is expected here from Australia.

HAROLD ALLMAN LEWIS has resigned as general manager of the Porco tin mines, Bolivia, owing to ill-health caused by the altitude of the mines, and has been appointed managing agent and consulting engineer to the Berenguela Tin Mines, Limited, with headquarters at Cochabamba. He is free to take consulting work in Bolivia, Chile, and Peru.

H. B. MAUFE has been elected president of the Geological Society of South Africa for the coming year.

THOMAS MULLETT has recently completed his 21st year of service as secretary of the British Broken Hill Company.

J. SCOTT PARK has returned from Nigeria.

GUY H. RUGGLES has been appointed metallurgist at the Inspiration copper mine, Arizona.

A. R. SAWYER has re-started No. 1 bore-hole which he is sinking for the New Rand, Limited.

E. GYBBON SPILSBURY has returned to New York from Cuba, where he has been studying the manganese position.

A. W. STICKNEY is going to Cyprus on oil business.

W. H. SUTTON has been appointed manager of the Mount Lindsay tin mine, Tasmania.

J. B. TYRRELL has gone to northern British Columbia.

SCOTT TURNER has received a commission in the United States Naval Reserve Force.

E. A. WALLERS has been elected a director of the Central Mining and Investment Corporation.

R. A. WHITE has been appointed instructor in geology and demonstrator in chemistry in the Bendigo School of Mines.

TRADE PARAGRAPHS

THE ELECTRICAL ALLOY CO., of 135, Broadway, New York, is making "Lucer," a new alloy of copper and nickel, intended as a substitute for German silver.

THE CONCRETE UTILITIES BUREAU, the office of which is 6, Lloyd's Avenue, London, E.C., has opened a permanent exhibition of concrete structures at 143, Grosvenor Road, near Vauxhall Bridge.

GEORGE F. WEST & CO., of 13, Victoria Street, Westminster, send us their catalogue. They are agents for the Bucyrus Company, of Milwaukee, and for the Western Wheeled Scraper Co., of Aurora, Illinois.

THE POWDERED FUEL PLANT CO. LTD. has been formed, with offices at 47, Victoria Street, Westminster, to acquire the European rights for several American processes for using powdered fuel in metallurgical furnaces and for steam-raising, known as the Holbeck, Fuller, Aero, and Muhlfeld systems.

THE OLIVER CONTINUOUS FILTER CO., of San Francisco, send us their latest catalogue. This vacuum filter, designed originally for the treatment of slime after cyaniding, has many other applications, of which the de-watering of flotation concentrate, and the removal of potash and nitrate solutions from blast-furnace dust and caliche respectively, are of the most interest to mining men.

THE HARDY PATENT PICK CO., LTD., of Sheffield, are putting on the market the "Water-Jack" hammer drill. The valve is of the spool type, air-thrown in both directions, without the intervention of any mechanical connection, such as a tappet. The blow struck by the piston is transmitted to the drill steel through an anvil block. Thus the steels need no collar and may be cut straight from the bar if hexagon steel is used, or formed with a plain square if round steel is preferred. The front head of the machine is fitted with a renewable bushing, so that machines can take either the hexagon or square shank as preferred. This renewable bushing offers considerable advantage in keeping down cost of upkeep. The machine is fed forward automatically on a simple pneumatic feeding device, thereby ensuring proper advance and relieving the operator of any hard work. The steel is not automatically rotated, but the machine is given a slight to and fro motion by means of a cranked handle. The bits are formed as cross or rose cutting edges, or may even be made as heavy double or single chisels, providing that the necessary to and fro motion is given to ensure a round hole. The absence of rotating gear ensures the maximum of simplicity in construction and economy in upkeep in the hardest ground. Water is fed through the anvil block, which is efficiently packed, and through the drill steel to the bottom of the hole being drilled. The supply of water is under the operator's control. The packing of the anvil block is readily renewable and is of the same type as used in connection with the firm's rotary hammer drills. It consists of two hydraulic U section rubber rings, held in position by a phosphor bronze distance piece, which acts also as an annular water feed from the hose to the anvil block. The machine may be mounted on bar and arm, giving universal adjustment in all directions, or may be used on the air feed only, without any other support, for overhead work.

METAL MARKETS

COPPER. — In this country prices have undergone no change, and the official figures continue at £110 to £110. 10s. for standard and at £125 to £121 for electrolytic. In America a decision has at last been reached in regard to the price question, and it has been resolved to continue the existing figure of 23½ cents for 75 days from June 1. Considerable dissatisfaction has been manifested at the decision, inasmuch as the costs of production have increased, and still continue to increase. The expense of some of the high cost producers is stated to be as much as 30c. It is difficult to see how these latter could be materially benefited by a price increase to 24½ cents, which was generally hoped for. On the other hand over 95% of the American output can be produced profitably at 23½ cents, and production is stated to be satisfactory, so that the Government seems fully justified in declining to raise the price. A committee of producers has been formed for their self protection. A conference took place at Washington between the War Industries Board and the producers at which the question was discussed of fixing a general refining charge between mining and refining companies. This appears to have been found impracticable owing to the variety in terms and conditions of contracts and further discussion has been postponed.

Average prices of cash standard copper: May 1918, £110. 5s.; April 1918, £110. 5s.; May 1917, £130. 5s.

TIN. — The appointment of a Director of Tin Supplies, the establishment of an organization for rationing and distributing requirements, and the restriction of exports has been followed by a welcome decline in prices. The month of May closed with the official price for standard at £349 to £350 as against £380 earlier in the month. Much higher prices have ruled in America and in the East; in the former for fear that the holding up of supplies from Batavia would lead to a further stringency, and in the latter where smelters, thinking they had the position in their own hands, advanced prices considerably against the American demand. With the fall in the London market the East has followed, encouraged no doubt by the resumption of the sailings from Batavia and the freer offering of Dutch metal. Considerable premiums have been secured for English tin in consequence of the strict control of Straits for export; this has been ended, however, by the Director of Tin Supplies restricting the premium that may be asked. The quality, however, is difficult to procure for early delivery, so great is the demand for shipment to France and America to replace higher grades. It is hoped now that the market is under close control that there will be no need for consumers to rush in and buy more than is immediately necessary.

Average prices of cash standard tin: May 1918, £364. 7s. 8d.; April 1918, £329. 18s. 1d.; May 1917, £245. 2s. 10d.

SPELTER.—The official price in this country is still £54 to £50. There is a moderate inquiry. In America prices are higher at 7¾ to 7½ c. for spot and 7·37½ to 7·62½ for July, but there is no sustained activity, although it is reported that accumulated stocks are being gradually depleted while production has been considerably curtailed.

Average prices of good ordinary brands: May 1918, £52; April 1918, £52; May 1917, £52.

LEAD.—There is no change in the official price which is £29. 10s. to £28. 10s. net or £30. 10s. 5d. to £29. 6s. 9d. full terms. The American market is fairly steady at 7 to 7¼ cents.

Average prices of soft foreign lead: May 1918, £29; April 1918, £29; May 1917, £30.

ALUMINIUM.—£225 per ton. NICKEL.—£220 per ton.

ANTIMONY. — English regulus £85 per ton; crude £43; ore 8s. to 10s. per unit.

QUICKSILVER.—£22. 10s. per flask of 75 lb.

BISMUTH.—12s. 6d. per lb. CADMIUM.—8s. per lb.

PLATINUM.—New 400s. per oz.; scrap 360s. per oz.

MOLYBDENITE.—105s. per unit, 90% MoS_2.

TUNGSTEN ORES.—60s. per unit, 70% WO_3.

SILVER.—Since the fixing of the price in the United States at a dollar per oz., the market has been steady. In this country the quotation has been 48⅞d. per oz. since May 13.

PRICES OF CHEMICALS. June 8

Owing to the war, buyers outside the controlled firms have a difficulty in securing supplies of many chemicals, and the prices they pay are often much higher than those quoted below.

		£	s.	d.
Alum	per ton	19	10	0
Alumina, Sulphate of	,,	18	10	0
Ammonia, Anhydrous	per lb.		1	10
,, 0·880 solution	per ton	34	0	0
,, Chloride of, grey	per cwt.	2	7	0
,, ,, ,, pure	,,	4	0	0
,, Nitrate of	per ton	75	0	0
,, Phosphate of	,,	130	0	0
,, Sulphate of	,,	17	10	0
Arsenic, White	,,	110	0	0
Barium Sulphate	,,	9	0	0
Bleaching Powder, 35% Cl.	,,	14	0	0
Borax	,,	42	0	0
Copper, Sulphate of	,,	67	0	0
Cyanide of Sodium, 100%	per lb.		1	0
Hydrofluoric Acid	,,			7
Iodine	,,		14	0
Iron, Sulphate of	per ton	17	0	0
Lead, Acetate of, white	,,	160	0	0
,, Nitrate of	,,	62	0	0
,, Oxide of, Litharge	,,	42	0	0
,, White	,,	46	0	0
Magnesite, Calcined	,,	14	0	0
Magnesium Sulphate	,,	14	0	0
Phosphoric Acid	per lb.		1	6
Potassium Carbonate	per ton	200	0	0
,, Chlorate	per lb.		2	3
,, Chloride 80%	per ton	55	0	0
,, Hydrate, (Caustic) 90%	,,	400	0	0
,, Nitrate	,,	70	0	0
,, Permanganate	per lb.		14	0
,, Prussiate, Yellow	,,		3	6
,, Sulphate, 90%	per ton	60	0	0
Sodium Metal	per lb.		1	8
,, Acetate	per ton	125	0	0
,, Bicarbonate	,,	8	10	0
,, Carbonate (Soda Ash)	,,	7	0	0
,, ,, (Crystals)	,,	4	5	0
,, Hydrate, 76%	,,	26	0	0
,, Hyposulphite	,,	51	0	0
,, Nitrate, 95%	,,	27	0	0
,, Phosphate	,,	75	0	0
,, Silicate	,,	11	0	0
,, Sulphate (Salt-cake)	,,	2	12	6
,, ,, (Glauber's Salts)	,,	4	0	0
,, Sulphide	,,	39	0	0
Sulphur, Roll	,,	21	0	0
,, Flowers	,,	23	0	0
Sulphuric Acid, non-arsenical 140°T.	,,	4	18	0
,, non-arsenical 95%	,,	7	10	0
Superphosphate of Lime, 18%	,,	5	0	0

STATISTICS.

Production of Gold in the Transvaal.

	Rand	Elsewhere	Total	Value
	Oz.	Oz.	Oz.	£
Year 1912	8,753,563	370,731	9,124,299	38,757,560
Year 1913	8,430,998	363,826	8,794,824	37,358,040
Year 1914	8,033,567	344,570	8,378,139	35,588,075
Year 1915	8,772,919	320,752	9,073,671	38,627,461
Year 1916	8,971,359	324,179	9,295,538	39,484,934
January 1917	756,997	25,637	782,634	3,324,418
February	696,955	24,366	721,321	3,063,976
March	760,598	26,496	787,094	3,343,363
April	717,598	25,180	742,778	3,155,121
May	753,531	26,034	779,385	3,310,618
June	732,799	26,925	759,724	3,227,101
July	731,848	25,991	757,839	3,219,094
August	731,405	25,253	756,658	3,214,079
September	712,881	25,350	738,231	3,135,807
October	724,846	26,444	751,290	3,191,279
November	698,271	24,568	722,839	3,070 426
December	697,137	25,282	722,419	3,068,639
Year 1917	8,714,866	307,527	9,022,493	38,323,921
January, 1918	694,121	19,991	714,182	3,033,653
February	637,571	22,188	659,759	2,802,477
March	677,008	19,273	696,281	2,957,614
April	697,733	19,366	717,099	3,046,045

Natives Employed in the Transvaal Mines.

	Gold mines	Coal mines	Diamond mines	Total
January 31, 1917	188,624	11,611	5,591	205,826
February 28	191,095	11,568	6,268	208,931
March 31	190,028	11,494	6,620	208,142
April 30	185,975	11,435	6,314	203,724
May 31	180,168	11,432	5,805	197,405
June 30	175,727	11,258	5,369	192,354
July 31	171,653	11,381	5,223	188,257
August 31	170,817	11,401	5,028	187,246
September 30	171,334	11,601	4,791	187,726
October 31	170,531	11,841	4,620	186,792
November 30	169,083	11,633	4,620	185,336
December 31	172,740	11,695	4,593	189,028
January 31, 1918	176,424	11,469	4,715	192,608
February 28	181,066	11,243	4,825	197,134
March 31	183,055	11,076	4,745	198,876
April 30	182,492	11,322	4,753	198,567

Cost and Profit on the Rand.

Compiled from official statistics published by the Transvaal Chamber of Mines. The profit available for dividends is about 60% of the working profit.

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
January 1917	2,337,066	26 10	18 8	7 11	941,520
February	2,153,691	27 3	19 2	7 10	841,259
March	2,430,590	26 7	19 0	7 4	879,351
April	2,235,833	27 2	19 2	7 8	857,710
May	2,405,855	26 4	18 7	7 5	887,527
June	2,288,426	26 11	19 2	7 7	867,639
July	2,294,668	26 11	19 0	7 7	869,577
August	2,301,892	26 9	19 0	7 6	859,517
September	2,195,884	27 5	19 4	7 9	848,096
October	2,280,461	26 10	19 5	7 2	814,211
November	2,156,814	27 4	19 11	7 2	775,502
December	2,130,510	27 7	20 0	7 4	783,729
January, 1918	2,167,411	27 1	20 7	6 4	703,665
February	1,946,338	27 8	21 7	5 11	577,396

Production of Gold in Rhodesia and West Africa.

	Rhodesia.		West Africa.	
	1917	1918	1917	1918
	£	£	£	£
January	296,113	253,807	131,665	107,863
February	289,734	232,023	104,892	112,865
March	300,183	230,023	158,727	112,605
April	297,977	239,916	123,825	117 520
May	299,271	—	121,104	—
June	302,195	—	114,489	—
July	288,731	—	142,017	—
August	294,359	—	130,278	—
September	291,367	—	127,168	—
October	289,978	—	126,295	—
November	275,829	—	126,915	—
December	270,616	—	122,602	—
Total	3,495,391	955,769	1,529,977	450,853

West Australian Gold Statistics.

	Reported for Export oz.	Delivered to Mint oz.	Total oz.	Total value £
January 1917	*	83,962	*	*
February	*	81,810	*	*
March	*	76,171	*	*
April	*	82,144	*	*
May	*	78,165	*	*
June	*	82,600	*	*
July	*	81,166	*	*
August	*	80,181	*	*
September	*	81,761	*	*
October	*	73,901	*	*
November	*	80,642	*	*
December	*	78,793	*	*
January, 1918	*	73,703	*	*
February	*	76,987	*	*
March	*	69 730	*	*
April	*	66,079	*	*
May	*	73,701	*	*

* By direction of the Federal Government the export figures will not be published until further notice.

The total yield at the mines for 1917 is reported at 973,316 oz.

Australian Gold Returns.

	Victoria.		Queensland.		New South Wales	
	1917	1918	1917	1918	1917	1918
	£	£	£	£	£	£
January	67,627	32,134	50,150	47,600	29,000	25,000
February	65,450	—	63,200	45,470	26,000	28,000
March	74,794	—	61,200	48,020	41,000	30,000
April	75,139	—	62,470	47,600	21,000	30,000
May	65,623	—	65,450	—	28,400	—
June	64,180	—	73,100	—	24,600	—
July	68,937	—	71,820	—	44,000	—
August	101,428	—	74,800	—	21,000	—
September	61,701	—	64,180	—	20,000	—
October	33,533	—	54,400	—	47,000	—
November	75,912	—	42,380	—	29,000	—
December	56,967	—	64,170	—	19,000	—
Total	846,540	32,134	744,537	188,690	349,000	113,000

Production of Gold in India.

	1915	1916	1917	1918
	£	£	£	£
January	201,255	192,150	190,047	176,030
February	195,970	183,264	180,904	173,343
March	194,350	186,475	189,618	177,950
April	196,747	192,208	185,835	176,486
May	199,786	193,604	184,874	—
June	197,447	192,469	182,426	—
July	197,056	191,404	179,660	—
August	197,984	192,784	181,005	—
September	195,952	192,330	183,630	—
October	195,531	191,502	182,924	—
November	192,714	192,298	182,388	—
December	204,590	205,164	190,852	—
Total	2,369,382	2,305,652	2,214,163	703,809

Daily London Metal Prices

Copper, Lead, Zinc, Tin, in £ per long ton. Silver in pence per standard ounce.

	Copper Standard	Copper Electrolytic	Copper Best Select'd	Soft For'n Lead	Zinc	Tin Standard	Silver
May	£	£	£	£ s.	£ s.	£ s. d.	d.
13	110	125	123	29 10	54 0	375 0 0	48⅞
14	110	125	123	29 10	54 0	370 0 0	48⅞
15	110	125	123	29 10	54 0	367 0 0	48⅞
16	110	125	123	29 10	54 0	364 0 0	48⅞
17	110	125	123	29 10	54 0	363 0 0	48⅞
21	110	125	123	29 10	54 0	360 0 0	48⅞
22	110	125	123	29 10	54 0	360 0 0	48⅞
23	110	125	123	29 10	54 0	355 0 0	48⅞
24	110	125	123	29 10	54 0	355 0 0	48⅞
27	110	125	123	29 10	54 0	355 0 0	48⅞
28	110	125	123	29 10	54 0	355 0 0	48⅞
29	110	125	123	29 10	54 0	355 0 0	48⅞
30	110	125	123	29 10	54 0	353 0 0	48⅞
31	110	125	123	29 10	54 0	350 0 0	48⅞
June							
3	110	125	123	29 10	54 0	349 0 0	48⅞
4	110	125	123	29 10	54 0	346 0 0	48⅞
5	110	125	123	29 10	54 0	331 0 0	48⅞
6	110	125	123	29 10	54 0	331 0 0	48⅞
7	110	125	123	29 10	54 0	331 0 0	48⅞
10	110	125	123	29 10	54 0	331 0 0	48⅞
11	110	125	123	29 10	54 0	329 0 0	48⅞

Imports of Ores and Metals into United Kingdom.

These figures now include Government imports.

* Statistics not published. Long tons.

	Year 1917	April 1918	Year 1918
	Tons	Tons	Tons
Iron Ore	*	*	*
Copper Ore	*	*	*
,, Matte and Precipitate	28,241	3,107	8,601
,, Metal	142,778	24,994	77,730
Copper and Iron Pyrite	*	*	*
Tin Concentrate	*	*	*
,, Metal	27,143	1,571	5,538
Manganese Ore	*	*	*
Lead, Pig and Sheet	147,124	27,603	85,672
Zinc (spelter)	76,105	8,686	30,062
	lb.	lb.	lb.
Quicksilver	2,172,434	—	304,655

Exports of Copper from United States

1917	Long tons	1917	Long tons	1918	Long tons
January	25,540	July	38,127	January	40,530
February	24,937	August	45,304	February	28,160
March	51,246	September	30,493	March	22,550
April	79,001	October	39,115	April	21,528
May	45,241	November	38,638	May	—
June	39,816	December	35,000	June	—
Total	265,783	Total 1917	484,120	Total 1918	112,768

Outputs of Tin Mining Companies.

In Tons of Concentrate.

	Year 1917	April 1918	Year 1918
	Tons	Tons	Tons
Bisichi (Nigeria)	278	25	115
Briseis (Tasmania)	237	24	112
Dolcoath (Cornwall)	863	—	202
East Pool (Cornwall)*	1,012	109	405
Gopeng (F.M.S.)	1,039	76	305
Malayan Tin (F.M.S.)	828	66	235
Mongu (Nigeria)	571	35	170
Naraguta (Nigeria)	503	—	146
N. N. Bauchi (Nigeria)	550	40	185
Pahang (F.M.S.)	2,612	159	651
Rayfield (Nigeria)	660	60	255
Renong (Siam)	1,023	39	253
Siamese Tin (Siam)	808	94	420
South Crofty (Cornwall)*	694	60	223
Tekka-Taiping (F.M.S.)	422	35	106
Tongkah Harbour (Siam)	1,229	109	375
Tronoh (F.M.S.)	1,046	107	407

* Including Wolfram.

Stocks of Tin.

Reported by A. Strauss & Co. Long tons.

	March 31, 1918	April 30, 1918	May 31, 1918
	Tons	Tons	Tons
Straits and Australian, Spot	1,190	1,604	1,634
Ditto, Landing and in Transit	—	325	525
Other Standard, Spot and Landing	438	464	499
Straits, Afloat	*5,000	*5,575	*6,650
Australian, Afloat	—	—	—
Banca, on Warrants	—	—	—
Ditto, Afloat	*3,655	*3,655	*3,470
Billiton, Spot	—	—	—
Ditto, Afloat	*300	*300	*300
Straits, Spot in Holland and Hamburg	—	—	—
Ditto, Afloat to Continent	*500	*500	*500
Afloat for United States	*9,246	*7,246	*6,001
Stock in America	134	64	363
Total Stock	20,463	19,733	19,942

* Estimated.

Shipments and Imports of Tin

Reported by A. Strauss & Co. Long tons.

	Year 1916	Year 1917	May 1918	Year 1918
	Tons	Tons	Tons	Tons
Shipments from:				
Straits to U.K.	27,157	28,099	2,200	*9,700
Straits to America	25,943	24,977	2,300	*13,300
Straits to Continent	8,487	9,290	500	*1,650
Australia to U.K.	2,537	349	—	—
U.K. to America	14,863	12,890	40	998
Imports of Bolivian Tin into Europe	15,116	19,209	824	5,463
Deliveries in U.K.	16,862	15,142	1,138	6,876
,, ,, Holland	943	1,714	—	*71

* Estimated.

Nigerian Tin Production.

In long tons of concentrate of unspecified content.

Note. These figures are taken from the monthly returns made by individual companies reporting in London, and probably represent 85% of the actual outputs.

	1913	1914	1915	1916	1917	1918
	Tons	Tons	Tons	Tons	Tons	Tons
January	466	485	417	531	667	666
February	427	469	558	528	646	653
March	510	502	418	547	655	686
April	430	482	444	486	555	490
May	360	480	357	536	509	—
June	321	460	373	510	473	—
July	357	432	455	506	479	—
August	406	228	438	498	551	—
September	422	289	442	535	538	—
October	480	272	511	584	578	—
November	446	283	467	679	621	—
December	478	326	533	654	655	—
Total	5,103	4,708	5,213	6.594	6,927	2,495

Production of Tin in Federated Malay States.

Estimated at 70% of Concentrate shipped to Smelters. Long Tons. * No monthly figures published since June, 1917.

	1913	1914	1915	1916	1917
	Tons	Tons	Tons	Tons	Tons
January	4,121	4,983	4,395	4,316	3,558
February	3,823	3,555	3,780	3,372	2,755
March	3,562	3,839	3,653	3,696	3,286
April	4,066	4,087	3,619	3,177	3,251
May	4,319	4,135	3,823	3,729	3,413
June	3,993	4,303	4,048	3,435	3,489
July	4,245	4,582	3,544	3,517	*
August	4,620	3,591	4,046	3,732	*
September	4,379	3,623	3,932	3,636	*
October	4,409	3,908	3,797	3,681	*
November	3,976	4,085	4,059	3,635	*
December	4,614	4,351	4,071	3,945	*
	50,127	49,042	46,767	43,871	39,833

Sale of Tin Concentrate at Redruth Ticketings.

	Long tons	Value	Average
July 2, 1917	159½	£21,661	£135 16 1
July 16	144¾	£18,896	£130 19 11
July 30	168	£23,225	£138 5 0
August 13	160¼	£21,757	£135 15 4
August 27	156½	£21,429	£136 18 6
September 10	160¾	£21,784	£135 18 9
September 24	153	£21,448	£140 3 9
October 8	160½	£22,160	£138 11 6
October 22	153	£21,712	£141 18 2
November 6	144¼	£21,063	£146 0 5
November 19	156	£24,737	£158 11 6
December 3	148	£24,609	£165 5 6
December 17	148½	£25,620	£172 10 7
December 31	151¾	£23,450	£154 10 8
Total, 1917	4,186	£561,003	£134 0 0
January 14, 1918	141	£23,563	£167 2 3
January 28	171½	£28,976	£168 19 2
February 11	166½	£29,674	£178 4 6
February 25	156½	£28,213	£180 18 4
March 11	178¾	£33,398	£187 7 4
March 25	169½	£31,253	£184 7 9
April 8	157¾	£29,575	£188 1 8
April 22	159½	£31 402	£196 17 7
May 6	172½	£39,999	£232 4 4
May 21	169½	£36,791	£217 1 2
June 3	172	£36,109	£209 18 9

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD, SILVER, DIAMONDS:	June 6, 1917 £ s. d.	June 6, 1918 £ s. d.
RAND:		
Bantjes	9 0	2 9
Brakpan	5 1 3	4 15 0
Central Mining (£8)	6 10 0	5 18 9
Cinderella	4 6	4 0
City & Suburban (£4)	1 12 6	16 3
City Deep	4 7 6	3 1 3
Consolidated Gold Fields	1 12 0	1 12 6
Consolidated Langlaagte	1 3 0	17 6
Consolidated Main Reef	17 0	15 3
Consolidated Mines Selection (10s).	1 4 9	1 7 0
Crown Mines (10s.)	2 11 3	1 18 9
Daggafontein	17 0	1 7 6
D. Roodepoort Deep	11 3	10 0
East Rand Proprietary	9 9	2 6
Ferreira Deep	1 0 0	13 0
Geduld	2 2 6	1 18 9
Geldenhuis Deep	1 3 0	13 9
Gov't Gold Mining Areas	3 0 6	3 13 9
Heriot	2 1 3	1 0 6
Jupiter	6 0	5 0
Kleinfontein	1 3 0	14 3
Knight Central	7 9	[illegible] 0
Knight's Deep	17 6	8 0
Langlaagte Estate	16 6	14 0
Meyer & Charlton	5 7 6	4 15 0
Modderfontein (£4)	21 10 0	23 0 0
Modderfontein B	7 15 0	7 13 9
Modder Deep	7 2 6	7 10 0
Nourse	1 2 6	17 6
Rand Mines (5s.)	3 8 9	2 15 0
Rand Selection Corporation	3 17 6	4 15 0
Randfontein Central	13 6	11 0
Robinson (£5)	1 1 3	15 6
Robinson Deep A (1s.)	1 12 6	1 3 9
Rose Deep	19 6	19 6
Simmer & Jack	6 9	5 6
Simmer Deep	3 6	2 9
Springs	3 0 6	3 17 0
Sub-Nigel	1 7 6	1 10 0
Van Ryn	1 18 0	1 1 3
Van Ryn Deep	3 5 6	3 11 3
Village Deep	1 5 6	19 6
Village Main Reef	14 6	12 0
Witwatersrand (Knight's)	2 2 6	1 5 0
Witwatersrand Deep	14 6	7 0
Wolhuter	10 0	5 0
OTHER TRANSVAAL GOLD MINES:		
Glynn's Lydenburg	14 6	19 6
Sheba (5s.)	1 3	9
Transvaal Gold Mining Estates	15 0	15 6
DIAMONDS IN SOUTH AFRICA:		
De Beers Deferred (£2 10s.)	13 17 6	12 17 6
Jagersfontein	4 5 0	4 1 3
Premier Deferred (2s. 6d.)	7 10 0	6 15 0
RHODESIA:		
Cam & Motor	8 9	12 6
Chartered British South Africa	12 0	15 0
Eldorado	8 3	7 3
Falcon	14 6	1 2 3
Gaika	8 6	15 6
Giant	5 3	7 0
Globe & Phœnix (5s.)	1 10 0	1 9 6
Lonely Reef	1 3 6	1 16 6
Rezende	1 0 0	4 2 6
Shamva	1 3 9	1 18 9
Wanderer (3s.)	2 0	1 0
Willoughby's (10s.)	5 6	4 9
WEST AFRICA:		
Abbontiakoon (10s.)	5 0	3 6
Abosso	9 0	7 6
Ashanti (4s.)	19 3	19 6
Prestea Block A	6 0	3 9
Taquah	17 0	14 6
WEST AUSTRALIA:		
Associated Gold Mines	3 0	3 0
Associated Northern Blocks	2 9	2 9
Bullfinch	2 0	2 0
Golden Horse-Shoe (£5)	1 18 9	2 3 9
Great Boulder Proprietary (2s.)	11 3	11 3
Great Boulder Perseverance	1 0	—
Great Fingall (10s).	1 0	1 9
Ivanhoe (£5)	2 2 6	1 15 0
Kalgurli	9 3	9 3
Sons of Gwalia	13 9	9 0

GOLD, SILVER, *cont.*	June 6, 1917 £ s. d.	June 6, 1918 £ s. d.
OTHERS IN AUSTRALASIA:		
Mount Boppy, New South Wales	6 0	5 0
Talisman, New Zealand	11 3	15 0
Waihi, New Zealand	1 14 6	1 16 9
Waihi Grand Junction, New Z'lnd	14 9	15 0
AMERICA:		
Alaska Treadwell (£5), Alaska	1 15 0	10 0
Buena Tierra, Mexico	10 0	13 0
Camp Bird, Colorado	6 6	10 6
Casey Cobalt, Ontario	5 6	9 0
El Oro, Mexico	9 0	[illegible] 0
Esperanza, Mexico	10 3	9 3
Frontino & Bolivia, Colombia	11 6	12 6
Le Roi No. 2 (£5), British Columbia	7 6	7 0
Mexico Mines of El Oro, Mexico	4 2 6	5 10 0
Oroville Dredging, California	15 9	19 3
Plymouth Consolidated, California	1 2 0	1 2 6
St. John del Rey, Brazil	17 0	16 6
Santa Gertrudis, Mexico	10 0	15 0
Tomboy, Colorado	18 9	17 0
RUSSIA:		
Lena Goldfields	1 15 0	1 5 0
Orsk Priority	1 1 3	12 6
INDIA:		
Champion Reef (2s. 6d.)	5 9	5 9
Mysore (10s.)	3 8 0	2 11 3
Nundydroog (10s.)	1 6 6	1 2 9
Ooregum (10s.)	1 0 0	18 3
COPPER:		
Arizona Copper (5s.), Arizona	2 10 0	2 6 3
Cape Copper (£2), Cape Province	4 5 0	2 10 0
Chillagoe (10s.), Queensland	3	1 3
Cordoba (5s.), Spain	3 0	[illegible] 6
Great Cobar (£5), N.S.W.	2 3	2 0
Hampden Cloncurry, Queensland	1 10 9	1 6 6
Kyshtim, Russia	2 1 3	17 6
Messina (5s.), Transvaal	10 0	8 0
Mount Elliott (£5), Queensland	6 0 0	3 5 0
Mount Lyell, Tasmania	1 5 9	1 7 6
Mount Morgan, Queensland	1 15 0	1 10 0
Rio Tinto (£5), Spain	61 15 0	66 10 0
Sissert, Russia	1 5 0	—
Spassky, Russia	1 15 0	18 9
Tanalyk, Russia	1 19 6	18 6
Tanganyika, Congo and Rhodesia	3 9 6	3 3 0
LEAD-ZINC:		
BROKEN HILL:		
Amalgamated Zinc	1 11 6	1 7 3
British Broken Hill	1 14 3	2 9 3
Broken Hill Proprietary (8s.)	2 5 0	3 11 6
Broken Hill Block 10 (£10)	1 2 6	1 17 0
Broken Hill North	2 13 3	3 3 0
Broken Hill South	8 5 0	11 2 6
Sulphide Corporation (15s.)	1 6 3	1 9 6
Zinc Corporation (10s.)	1 0 6	1 7 6
ASIA:		
Burma Corporation	4 0 0	4 5 0
Irtysh Corporation	1 17 0	18 0
Russian Mining	17 6	8 6
Russo-Asiatic	4 8 9	2 2 6
TIN:		
Aramayo Francke, Bolivia	1 13 9	2 6 3
Bisichi, Nigeria	16 0	15 6
Briseis, Tasmania	5 6	6 0
Dolcoath, Cornwall	[illegible] 9	11 9
*East Pool, Cornwall	2 0 0	1 9 6
Ex-Lands Nigeria (2s.), Nigeria	2 0	2 6
Geevor (10s.) Cornwall	11 3	1 3 6
Gopeng, Malay	1 11 3	1 17 6
Ipoh Dredging, Malay	16 3	18 0
Malayan Tin Dredging, Malay	1 18 9	2 2 6
Mongu (10s.), Nigeria	14 0	16 6
Naraguta, Nigeria	14 3	18 0
N. N. Bauchi Pref. (10s.), Nigeria	9 9	12 9
Pahang Consolidated (5s.), Malay.	11 9	13 0
Rayfield, Nigeria	7 0	13 9
Renong Dredging, Siam	2 7 6	2 2 6
Ropp (4s.), Nigeria	18 3	1 5 0
Siamese Tin, Siam	2 15 0	3 0 0
South Crofty (5s.), Cornwall	1 0 6	2 12 0
Tekka, Malay	3 2 6	3 15 0
Tekka-Taiping, Malay	2 17 6	3 15 0
Tronoh, Malay	1 6 3	1 15 0

* £1 shares split into 4 of 5s. each in August 1917.

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers; also reviews of new books, and abstracts of the yearly reports of mining companies.

POROUS ZINC-FURNACE CHARGES.

At the February meeting of the American Institute of Mining Engineers, Woolsey McA. Johnson presented a paper describing his method of improving the physical condition of the charges of zinc-smelting furnaces, with the object of reducing the amount of carbonaceous material employed. The author grinds the ore and fuel fine and binds them into porous briquetets. This paper may be read in conjunction with Mr. Gilbert Rigg's article elsewhere in this issue.

In typical American zinc works a charge of roasted zinc ore with a side mixture of carbonates and silicates, analysing on the average 50% Zn, is mixed with 55% or more of its weight of a mixture of coal and coke analysing 60% to 70% fixed carbon. The ore is of varying fineness and the coal and coke are usually crushed in a semi-moist condition through a ⅜ in. screen. With ores of a slaggy nature, the coal proportion is increased, sometimes to as much as 100% of the weight of the ore. With carbonate ores, or where anthracite screenings with higher carbon content are cheap enough, the percentage of reducing agent is cut to 45% or even somewhat lower. The average charge per retort for a monthly run of a plant on ore, as distinguished from retorts on blue-powder, ladle-skimmings, and other between-products, runs from 60 to 66 lb., with a mean of 63 lb. for the South-west with standard retorts of 8½ in. inside diameter and 50 in. long inside using roasted sulphide ores. Conditions will change these figures, but 40 lb. of ore per cubic foot of retort space is an average in the better-operated plants. Since the rise in the price of spelter, the tendency has been to overcharge. To remove the slag that is formed when retorts are overcharged, extra men are put on to "gum-chisel" the retorts to prevent "set" furnaces and "butchered retorts."

From the foregoing it is clear that from four to six times the amount of coal necessary for the reduction is used, as is evidenced by the fact that the residues analyse as high as 35% fixed carbon. There are good reasons why this excess of fixed carbon must be used. These can be best explained by a description of the metallurgical requisites of a zinc charge. These may be enumerated as follows:

(1) High reducing power, especially at the end of the shift, to reduce any carbon dioxide to monoxide and bring about a good condensation of the vapour. It is, of course, well known that carbon dioxide, if formed in the retort, oxidizes the zinc vapour at lower temperatures and is the cause of the formation of an excessive amount of blue-powder.

(2) Heat conductivity as high as possible, so as to permit the heat, as soon as it permeates the walls of the retort, to flow to the inside of the charge in order that as uniform a temperature as possible may be attained in the retort. For this reason large pieces of coal, ore, and coke are charged, since fine material is a poor conductor of heat.

(3) If the charge be too dense, the back pressure of the gases produced is so great that the reduction is hindered. Moreover, the porosity allows the secondary gaseous reduction to proceed.

(4) The charge must leave a residue that is substantially non-slagging in character. Since carbon is infusible, this can be attained by having sufficient fine carbon present in the charge to leave particles of carbon in the residue. Since the fine particles are predominantly consumed or oxidized in the reduction of ZnO, these must be present to a certain excess in order to leave enough fine coal particles at the end to act as a sponge and stop any slag from attacking the retorts.

In the author's work on electric smelting where only 12% of coal was added, it was shown that it was possible, operating on a fairly large scale—1 ton of charge per day—to reduce zinc ore successfully with only the theoretical amount of coal. This seemingly incongruous fact points the way for certain improvements in the ordinary reduction of zinc ore in the retort. Accordingly investigation and research were started. Coal-dust firing, used successfully in the cement and smelting industry, was taken as a pattern. In this, the almost instantaneous oxidation of carbon is attained by the use of coal in the form of dust. Since any reduction process is likewise an oxidation process, it is not fanciful to regard zinc reduction as an oxidation of the "charge" coal. Accordingly, tests were made, grinding both the zinc ore and the coal to 80 mesh and finer. These fine mixes were worked off in a crucible or in a retort, and while they brought out certain advantages, they also showed conclusively that the fine charge had the disadvantage of being so dense as to hold back the zinc vapour and gases and so to diminish the speed of reaction. In the conventional furnace, large pieces of coke are put in to "ventilate" the charge. Accordingly, an addition was made of broom straw. These give a carbonized skeleton that is preserved during the retorting operation and provide a path for the gases so that they have a way of exit. Moreover, these carbonized skeletons or eductors are an ashless and very active form of carbon, and thereby reduce the carbon dioxide to carbon monoxide. Since the flow of the gases naturally takes to these eductors, it will be seen that this super-reduction is efficient in improving the condensation.

In these tests the percentage of reducing material was gradually decreased from 60% to 50, 40, 30, 25, and 20% successively and it was found that with complete reduction (residues analysing from 2 to 0·5% Zn) there was no slagging of the ore, provided the proportion of coal was left above 20%, unless the ore was specially slaggy. For instance, using an ore analysing Zn 22%, Fe 33, S 3·8, SiO_2 6·4, CaO and alkali 4% with 20% anthracite, there was slight fritting, but none with 25% of coal. In general, with reducing coal analysing fixed carbon 67·0%, volatile matter 26·6, ash 12·4% and an ore analysing Zn 43·5%, Fe 7·10, CaO 4·0% or even more, there is no trouble in getting residues that contain absolutely no "gum" or slag and analysing in zinc as follows: 2·1%, 0·6, 2·9, 2·1, 1·8, 0·5%. The ore charge per retort was thus raised to 100 lb. and the coal percentage reduced to 30% or lower. The reason for this is that the charge is highly reductive, due to its fineness, and the peculiar way it is "ventilated," and since the immense number of fine particles of carbon left at the end hold up the slag-making particles and any iron sulphides, little gum is formed, and if formed it does not touch the retort walls. Instead of the carbon particles passing through the process without oxidation, many of them ⅜ in. in diameter, and without performing any useful purpose, the surface of the particles is increased 40 or 50 fold. Remembering that in zinc reduction two solid reagents must be made to combine, the great theoretical advantage of a finely-ground porous charge is obvious.

For practical working, however, a charge must be a fair conductor of heat, for zinc reduction is heat-absorbing. This fineness of the charge, while it certainly promotes the reduction if properly "ventilated," makes the charge a poor conductor of heat, which is a decided disadvantage in the practical retorting operation. This poor conductivity is overcome by briquetting, which causes a certain lessening of the volume, but at an expense of \$1·50 per ton of ore. But since the density of coal is less than half that of the ore, the reduction of the percentage of coal from 60 to 30% or less increases the pounds of zinc ore per cubic foot from 42 to 63 lb., or increases the charge per retort from 67 to 100 lb.

The briquetting needs a special binder and, after mixing, can be effected by extruding through a pug mill, followed by warming or heating, leaving a partially reduced mass in various sizes suitable for charging in the conventional manner. The size of these kernels should be about ½ in. in diameter.

THE CASCADE METHOD OF FLOTATION.

In the *Mining and Scientific Press* for April 13, H. Hardy Smith discusses the principles of the cascade method of flotation, and describes the various systems introduced or proposed. The credit for first recognizing the principles underlying the cascade process, and for embodying them in practical form, is due to Messrs. Seale and Shellshear, of the Junction North mine at Broken Hill, Australia, where a full sized working plant was put into operation about the end of 1914. (The Seale-Shellshear process was described in the Magazine for August and December, 1917). As frequently happens, the same idea was hit upon and developed independently at practically the same time in other widely separated localities, namely, at the Arizona Copper Co. in the United States (the Crowfoot machine at the Arizona Copper Co. was described in the Magazine for June, 1917), and at the Suan mine in Korea. Later, in 1916, U.S. Patent No. 1,187,772 was taken out by G. E. Ohrn, and another, No. 1,202,512, by Gustaf Gröndal, both of Sweden, for apparatus embodying the cascade principle. About the same time a simple machine of true cascade type was evolved at the Mineral Farm mill, at Ouray, Colorado. (The Wilfley machine used here was described in the Magazine for July, 1917.) Recently Commonwealth Patent No. 2353 of 1916 was taken out by L. V. Waterhouse, of Mt. Lyell, Tasmania, for a novel form of the Ohrn machine. Although all the contrivances developed by the various investigators contain the same fundamental principles, the method of application differs widely. With some of the plants it is claimed that violent preliminary agitation and mixing of the flotation reagents with the pulp is unnecessary, but in most cases it will be found that this is highly desirable. The excellent mixing and emulsification which can be obtained by grinding the ore with the reagent in a tube-mill, in certain cases, may be sufficient, but supplementary agitation of the pulp, diluted to a consistence suitable for flotation, will not, in the general run of cases, be found amiss. In the apparatus developed at the Junction North mine, followed by other mines at Broken Hill, and by the Arizona Copper Co., as well as at Suan, and at Mineral Farm, the force of gravity alone is relied upon to inject the air and to disseminate it through the pulp. If insufficient natural fall is available, artificial fall must be created by means of elevators or pumps, which, at the same time, can be relied upon to provide a certain amount of the desirable preliminary mechanical agitation. In the Ohrn and Gröndal forms, the energy of high-pressure steam is employed, and in the Waterhouse machine, that of high-pressure water or solution. In these latter types it is safe to assume that preliminary violent agitation is not so vital, since the energy expended within the machine itself is greater than in the simple gravity types.

The necessity for providing equalizing apparatus at the head of the plant is even more important in the case of the cascade process than in other flotation processes, especially with gravity plants, since the nature of their operation makes them very sensitive to fluctuations in the volume of the feed. This lack of flexibility is one of the chief disadvantages of the process. A plant once designed for a certain tonnage, or more correctly, for a certain volume of pulp per unit of time, will not work satisfactorily at points much above or below this volume, and adjustments to suit altered conditions are not readily made.

In certain cases the froth produced in the cascade process is extremely evanescent, and if allowed to occupy areas approaching those used with other flotation processes, the result will be failure. Where disappointing results have been obtained in trials with the process, it is fairly safe to assume that this was one of the points not fully comprehended. The ratio of frothing area to capacity is one of the most important considerations in the design of a plant. On account of the frail froth that is liable to be encountered, another important thing is to provide for short travel and rapid removal of the froth-concentrate. A cascade machine, in the design of which proper attention has been paid to the above two points, will be found particularly efficient on coarse material, or in preferential flotation. In the case of a relatively high-grade pulp, containing a large proportion of readily floatable sulphide slime, the points mentioned may not be of such importance.

Turning to the mechanical details, Fig. 1 is a diagrammatic sketch of the simplest type of apparatus, and the only one which is accurately described by the name cascade. Its chief recommendation is its simplicity. The feed-apron spreads the moving liquid into a sheet, and although this gives a large area, it is not the maximum area in contact with air that the same volume of liquid could provide. This would lead to the supposition that the efficiency of the machine is not high. In the one developed at the Mineral Farm mill, not even crowding-boards were employed, the apron simply discharging into a box of square section, and the float being skimmed off continuously by a paddle. The results are said to be quite satisfactory. The capacity of a plant depends on the length of the frothing-boxes, and the intensity and time of treatment on the number of steps or cascades. Both can be increas-

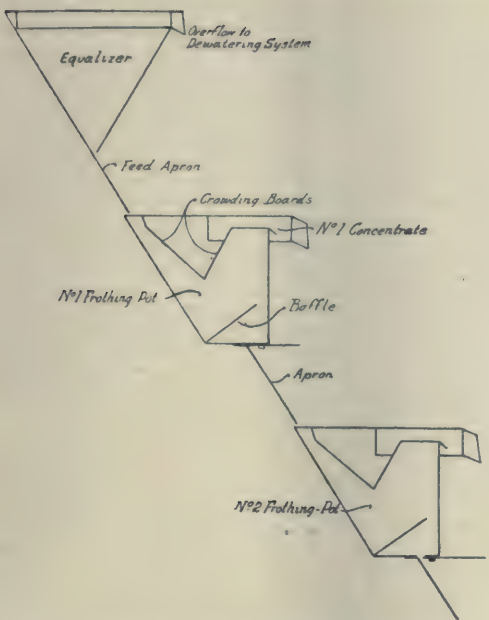


FIG. 1. SIMPLE TYPE OF CASCADE FLOTATION PLANT AS USED AT MINERAL FARM.

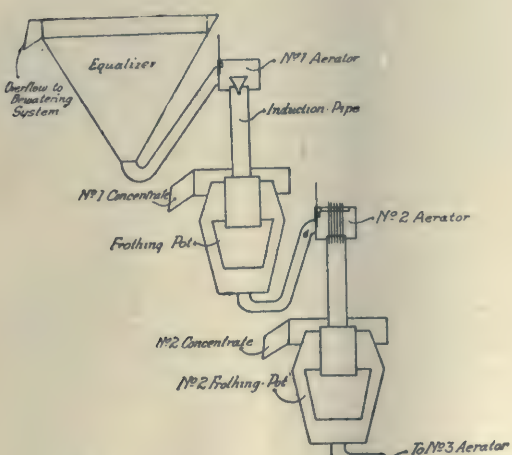


FIG. 2. TYPE USED AT JUNCTION NORTH AND SUAN MINES.

ed indefinitely, but it is preferable to have not more than six steps in succession, and, if further treatment is necessary, to interpose an elevating device to raise the pulp to the next tier. The frothing-boxes must be properly designed to suit the hydraulic head of each step, otherwise a loss of energy will result. This applies to all types of gravity machines. With the type shown in Fig. 1, a 30 to 40 in. head will usually be sufficient.

A more advanced type of apparatus is represented in Fig. 2. In most cases this could be expected to yield better results than the arrangement shown in Fig. 1, yet it is open to the objection that it involves more mechanical complication, and there is a loss of

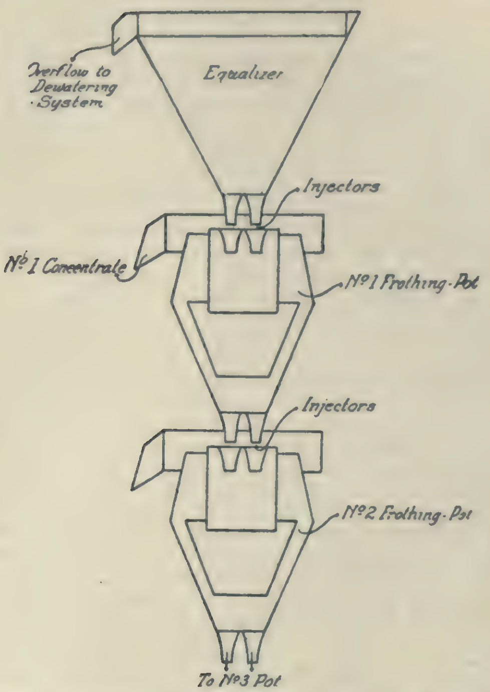


FIG. 3. TYPE USED AT ARIZONA COPPER CO., AND CENTRAL MINES, BROKEN HILL.

head between the steps, in consequence of which the total fall may not be utilized to the greatest advantage in the aerators. The capacity of the plant depends upon the dimensions of the induction-pipe and the frothing-pot. These cannot be increased indefinitely, so that a multiplication of units is necessary for a large tonnage. Very large volumes of air can be entrained by means of the induction pipe, either with or without the small air-pipes shown in the aerator in Fig. 2, and this part of the apparatus is undoubtedly efficient both as an aerator and as an agitator, in combination with its bucket or diaphragm. A length of induction pipe of 25 to 30 in. in the clear will usually give good results, but to get the total height between steps, the loss of head in the aerator (6 to 8 in.) and in the underflow pipe from the preceding frothing-pot must be added to it. The latter will depend on the density and coarseness of the pulp under treatment, but it will usually not be satisfactory at less than 12 in. Individual small frothing-pots have the advantage of providing a rapid discharge for the concentrate, and this apparatus is therefore well adapted to coarse material, to refractory ores, or to preferential flotation. The machines developed at the Junction North mine, Broken Hill, and at the Suan mine, Korea, are of this type.

Another type, corresponding to what was developed at the Arizona Copper Co.'s mill, and at the Central mine at Broken Hill, is shown in Fig. 3. Considerable difference of opinion may arise over the relative merits of the two types represented by Figs. 2 and 3, but as they come into more general use, admitting the comparison of operating results, doubtless one will become popular at the expense of the other. With two pots working side by side, one fitted with jets and the other with an induction pipe, although the froth had a different appearance, the amount of concentrate coming over seemed to be the same. The apparatus shown in Fig. 3 has the advantage of less complication and practically no loss of head, but the jet-injectors must be carefully designed and the nozzle needs frequent renewal. It is found that 30 to 40 in. head, and ⅝ to 1 in. nozzles, will give satisfaction. When a rapid froth removal is necessary it is desirable to have small individual pots, either of square or round section. Common oil-barrels make satisfactory pots of this class. With many ores, especially where large tonnages have to be treated, oblong pots would be preferable, the length depending on the tonnage that it is desired to treat in each unit. Very long pots are liable to be unsatisfactory on account of the difficulty of distributing the feed evenly.

One of the latest developments in the cascade type of machine is shown in Fig. 4. It is covered by the Waterhouse patent. A high-pressure liquid jet is used, both to inject air and to agitate the pulp. This machine will doubtless be elaborated and brought to a high state of metallurgical and mechanical efficiency. A pressure of about 80 lb. is used at the jet, and this pressure can be obtained by using a pump, as seen in the sketch. Since only solution and the finest suspended slime passes through the pump, the wear and tear are not excessive. The frothing-pot is made deep, and is fitted with baffles to confine the violent agitation to the lower part of the vessel. The frothing compartment is usually oblong in shape, and the single pump supplies several jets with high-pressure liquid. To get multiple treatment of the feed, each jet discharges into its individual pocket, which is separated from the succeeding pocket by a partition over which the pulp has to travel in order to reach the final pocket where it is discharged. The flotation reagents should be thoroughly mixed with the pulp before being fed into the separating tank, since it is preferable that the high-pressure liquid used at the jet should carry its proportion of frothing-agent before injection.

The apparatus shown in Fig. 5 presents a radical change from the preceding types, but its governing principles bring it within the cascade classification. In this case the stream of fluid that entrains the air and causes the agitation is not a liquid but a vapour, namely, high-pressure steam, the energy of which is utilized by means of a steam-jet injector. On account of the very low thermo-dynamical efficiency of the latter, this machine cannot be economical except when steam has to be used in any case to heat the pulp. In that special field it had a promising future. Oil is mixed with the steam before it strikes the pulp by being drawn into the jet through the small pipe shown in the sketch. It is claimed that better distribution of the oil is obtained in this way, and the claim is well founded, because the heated and atomized oil should certainly possess great covering power. The jet not only forces in the air for the bubbles, but also injects the pulp into the machine. The exact object of this is not clear, but, in the case of multiple treatment, it would make it possible to have the series of units on the same level, the tailing from one being led into the feed-hopper of the next. This type of machine is covered by the Ohrn patent.

The ideas covered by the Gröndal patent are similar to those embodied in the Ohrn apparatus, except that the oil is forced into the steam-pipe, and the mixed steam and oil then pass to a Koerting steam jet apparatus where air is drawn in. The steam, oil, and air become thoroughly commingled, and the mixture is led to the bottom of the agitating compartment, which it enters through a funnel-shaped orifice. Unlike the Ohrn machine the pulp is fed direct into the agitating compartment over the mouth of the funnel. After violent agitation in one chamber, resulting from the entry of the steam-oil-air mixture, the pulp passes to another, where the froth and tailing separate and are removed. The method of feeding the pulp direct into the agitating compartment, instead of through the injector, seems to be preferable, except in the case of the multiple treatment above mentioned.

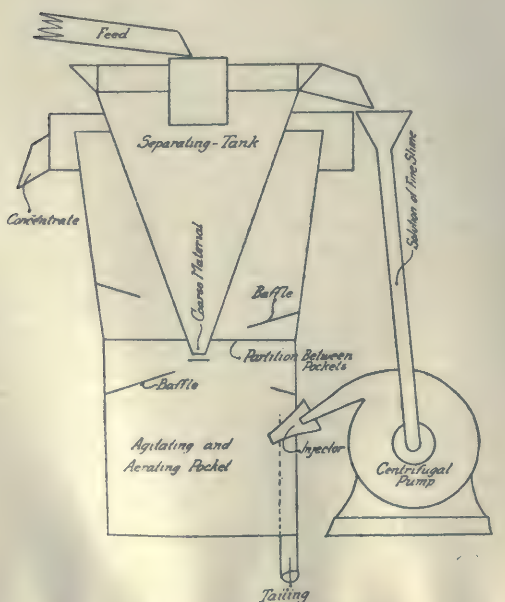


FIG. 4. WATERHOUSE METHOD.

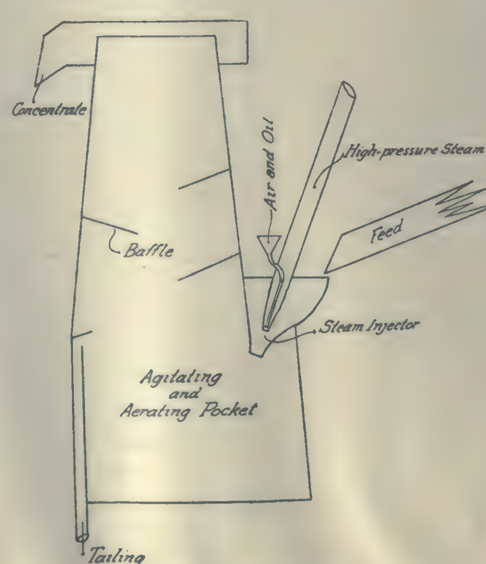


FIG. 5. OHRN METHOD.

THE ORIGIN OF WOLFRAM DEPOSITS.

Dr. W. R. Jones, representative in Burma of the High Speed Steel Alloys Co., Ltd., recently delivered a lecture at Tavoy, under the auspices of the Government Mining Advisory Board, on the origin of wolfram. It was partly elementary in form, as befitted an address to a general audience, but it also contained the exposition of a theory of origin that promises to constitute an important contribution to economic geology. We have condensed the lecture, but have preserved the method of exposition.

It has been shown that the minerals which can be prepared artificially fall into two classes, namely (1) those which are formed by dry fusion, that is, from a molten magma without the intervention of water or any fluxes, and (2) those which require, as an essential part of the process, the use of fluxes or solvents. Those minerals which can be formed from dry fusion characterize the basic igneous rocks, while those requiring the help of fluxes and solvents characterize the type of acid igneous rocks with which wolfram is associated both in Tavoy and Mergui districts, in Cornwall, and wherever tin-ore and wolfram occur. It is clear, therefore, that the origin of the wolfram, tin-ore, and associated minerals found in the Tavoy district is closely and definitely related to the fluxes and solvents which emanated from the granite magma.

Some of the fluxes probably acted as catalysers, that is, they promoted combination and may, or may not themselves, have entered into the composition of the resulting mineral; and catalysis can, perhaps, offer an explanation, in certain cases, of the influence of such mineralizers as fluorides, chlorides, borates, tungstates, vanadates, and others. These fluxes, which may be called "mineralizers" or "mineralizing gases and mineralizing solutions," in addition to being powerful solvents, had also very far-reaching chemical functions, and there is little doubt that such minerals as tin-ore, wolfram, scheelite, molybdenite, bismuth, bismuthine, pyrite, mispickel, and some other minerals common in the lodes in Tavoy were formed through the agency of magmatic gases and solutions.

The cooling of granite such as that at Tavoy under some thousands of feet of strata enabled all the molecules to aggregate themselves to form various minerals such as quartz, felspar, and mica, which are easily distinguishable. Deep down in the earth's crust, under the wolfram and tin mines and granite ranges of Burma and Malaya, there was at some geological age, almost certainly Post-Carboniferous and probably Pre-Tertiary, a place of local fusion where the molten magma, if chemically analysed, would have shown a composition very like that obtained from the chemical analysis of the present granite; but not exactly, for when that molten magma was pushed up, or forced itself up, to the overlying strata it was not all intruded as one huge mass of homogeneous composition.

The first part of the magma to be intruded into the overlying strata was that which now forms the bulk of the granite ranges, that is, the magma which, after consolidation, has given the enormous mountain ranges which in all probability stretch from the Southern Shan States to Tavoy district, southwards to Mergui district, thence into the Malay States, and through Johore toward Singapore and into the islands of Banca and Billiton. The magma that was left was considerably more acid in composition, and when the first intruded magma was in its final stages of consolidation, and when fissures had been formed in it due to shrinkage when cooling, and to the various stresses set up, the residual acid magma was intruded into, and filled these fissures, and also the numerous fissures formed in the adjacent rocks, namely, the mica schists, quartz schists, and phyllites, which together with the granites, form almost the whole of the rocks in the mining areas of the Tavoy district.

But this acid magma, this watery acid mother-liquid, was rich in mineralizing gases and solutions which had concentrated from the magma originally in the intercrustal reservoirs, and these mineralizers followed immediately, and often accompanied, the intrusion of the very acid magma. When they reached a temperature zone sufficiently cool, the wolfram, tin-ore, molybdenite, bismuthine, pyrite, mispickel, and a host of other minerals were deposited. Just as the fractures in the granites occur near the peripheries of the granite masses, so also do the wolfram and tin-ore occur where the chilling was greatest. This is why the hanging and foot-walls of the Tavoy lodes are, as a general rule, the richest parts of a lode, and why also, as a general rule, the narrow lodes and stringers of the district carry considerably higher percentages than do the wide lodes. There are exceptions, however, for some lodes have been enriched by a later intrusion, and lodes are also known to carry large lumps of wolfram well toward their middle parts, but these facts do not really militate against the general proposition.

These mineralizing gases and solutions do not always confine themselves to the fissures just occupied by the magma consolidating into pegmatite and quartz, but often, and far more frequently than is realized on several mines in Tavoy, attack the rock beyond the well defined walls of the lodes, so that rock also becomes mineralized. The greisen, for example, for a few inches on both sides of certain lodes occasionally carry over 1% of wolfram tin-ore concentrates and the rock beyond the quartz and pegmatite should be tested at least in a few places for every lode.

Neither did these mineralizing gases all remain in the mother-liquor until after the intrusion of the residual acid magma, but in some cases escaped with the first main intrusion, so that cases are known in the Tavoy district where wolfram and tin-ore occur as primary minerals in an otherwise ordinary granite, but such occurrences are exceptional. On the other hand, not all the magmas intruded into the fissures were accompanied or immediately followed by mineralizing gases and solutions in quantity, so that many quartz veins occur in the Tavoy district which are almost unmineralized and it is misleading to refer to these as lodes or reefs. They are merely quartz veins.

It is a popular fallacy to suppose that the pegmatite and quartz veins were intruded when the magma was at some extraordinarily high temperatures. The mineralizing gases and solutions, in addition to their other chemical functions, acted as powerful fluxes, and the crystallization of the magma probably took place at relatively low temperatures. There is very strong evidence in favour of this view and hardly any against it. It was the presence of these fluxes that enabled the magma to be intruded into the narrow fissures now forming quartz and pegmatite veins, and extending several hundreds of yards into the adjacent schists and phyllites, where the cooling effect of the country rock must have been very great. It is most important to bear this in mind when investigating the question of persistence at depth of wolfram.

It is not possible here to discuss the nature of the mineralizing gases and solutions that acted as "carriers" for the wolfram, tin-ore, molybdenite, bismuth, bismuthine, pyrite, mispickel and other minerals found in the Tavoy lodes. But it may be said that whereas in Malaya there is strong evidence, from the abundance of such fluorine-bearing minerals as tourmaline, topaz, and fluorspar, of assigning to the fluorides a most important role as "carriers" of tin-ore, the evidence in Tavoy district is in favour of regarding sulphides as having played a most important part as "carriers" of wolfram and tin-ore. This is clearly shown by the sulphide-bearing minerals with which wolfram and tin-ore are so often associated in this district and by the general absence of fluorine-bearing minerals. Mr. Coggin Brown, the Government Mining Adviser, has been like a sleuth-hound after tourmaline, and has so far found very little in the Tavoy district, whereas in Malaya so common is it that the Chinese coolies refer to it as the "friend of tin"; it is extremely common on almost all the Malayan tin-mines. It is interesting and significant to find that at Mergui, which is between the Tavoy and Malayan fields, tourmaline is fairly common and so are sulphide-bearing minerals. The author states that he has formed the opinion that both wolfram and tin-ore may have had certain other important "carriers," and also probably some of the silica in the lodes, in addition to that intruded as a molten magma, was deposited from mineralizing gases and solutions.

Evidence is rapidly accumulating that in general wolfram was deposited at lower temperatures than was tin-ore, and a striking proof of this is the fact that it would appear that when wolfram is found with no tin-ore, or mere traces of tin-ore, in Tavoy district, it is in those lodes in schists and phyllites farthest removed from the granite contact. In this district the outcrops of schists and phyllites as "caps" on the granite are extensive, whereas in Malaya there are relatively only a small number of outcrops of schists and phyllites still left capping the granite. The most notable of these outcrops is that which caps Gunong Tahan, the highest peak in Malaya. These facts strongly support the author's previous suggestion that the probable reason why Lower Burma carries more wolfram in proportion to tin-ore than does Malaya is that the lower part of the Malay Peninsula has suffered greater denudation than has Lower Burma, and that at Mergui, which is between the Tavoy and Malayan mines, the proportion of tin-ore to wolfram is greater than in the Tavoy district, and less than in Malaya. This theory has to be taken in a broad and general way, for even in the Tavoy district there is one mine which carries tin-ore with no wolfram, others in which the ores are present in almost equal proportions; and in the Mergui district one or two mines carry wolfram with very little tin-ore, whereas the Titi tin mine in Negri Sembilan, Malayan, differs from almost all the other Malayan tin mines in carrying a very high percentage of wolfram in the tin-ore. These mines, however, have interesting peculiarities which, instead of militating against this theory of unequal denudation strongly support the theory that relative proportions of tin-ore and wolfram are clearly related to the temperature zones in which the ores were deposited.

If this hypothesis is correct it means that we are to-day mining in Lower Burma the outcrops which have for the most part been denuded away in Malaya, and that we probably have at depth deposits more after the nature of those which occur *in situ* in that country and have been the source of its famous tinfields. There is direct evidence from the mines at work in the Tavoy district in support of this hypothesis. Many engineers will agree that the percentage of tin-ore on a few mines is already becoming greater. This need not alarm any one, for although there may be a few mines working at a zone where there is a slight change in the nature of the ore, the majority of the mines are probably at a zone several hundreds of feet above the part where the temperature was too high for the deposition of wolfram as the predominant ore. The author does not suggest that wolfram will, in all cases, give place below certain depths to tin-ore, because it does not necessarily follow that increase in depth must mean a higher temperature zone. In a centrally compact and extensive boss of granite, for example, the temperature in its interior before consolidation would probably be considerably higher than would be the case in the magma filling fissures near its peripheries even at much greater depths, and especially where several such infillings of fissures crossed one another. The case of the lode at Sadisdorf in the Erzgebirge tinfields in which tin-ore actually gives place at depth to wolfram is an interesting exception to prove the rule, but no explanation has been given to account for that phenomenon. Possibly the temperature below the tin-ore zone was, at the time of deposition, actually lower than it was above that zone from causes which are not inconceivable. The author showed a specimen from Tavoy district in which tin-ore crystals have actually been deposited on wolfram, leaving no doubt whatever that the wolfram had already been deposited before the deposition of the cassiterite. It is a specimen of extraordinary interest as showing the exceptional in nature.

GRAPHITE IN SOUTH AFRICA.

In the *South African Journal of Industries* for February, Dr. Percy A. Wagner writes on the occurrence of graphite in South Africa. At the present time the output is very small and there is no immediate prospect of any big increase. Nevertheless, owing to shipping restrictions a large part of the South African demand is being met locally, so that the industry stands a fair chance of development.

Though graphite is widely distributed throughout the older rocks, only one occurrence has so far actually been found worthy of exploitation. This is situated on the farm Goedehoop No. 223, in the eastern portion of the Zoutpansberg district of the Transvaal, about 20 miles east of Groot Spelonken Siding, and is being worked by the Transvaal Graphite Mining and Manufacturing Company, Ltd. The deposit takes the form of an attenuated lens with an average thickness of about 10 ft., which has been proved along the strike for a distance of 250 ft. The foot-wall of the lens is formed by what, in hand-specimens, appears to be decomposed pyroxenite, and it is overlain by schistose quartzite, striking from east to west and dipping at an angle of 55° to the south. The graphite deposit conforms in dip and strike with the quartzite. The rock referred to as pyroxenite encloses crystals and flakes of graphite, and may be genetically related with the deposit. The greater part of the lens appears to consist of amorphous or, more correctly speaking, finely crystalline massive graphite, which, especially near the foot-wall of the deposit, is traversed by narrow veins of flake graphite and encloses pockets of that mineral. The veins are up to ⅜ in. in thickness, and are made up entirely of flaky and columnar individuals of graphite arranged at right angles to their walls. In some of the pockets graphite showing crystal faces was noted. The amorphous graphite, though generally stained with iron, is, on the whole, fairly pure except near the hanging wall of the lens, where it appears to be mixed with arenaceous matter. A series of representative samples taken some time ago assayed from 50 to 90% of carbon. The deposit has been opened up by means of an inclined shaft and tunnels, and a vertical shaft is now being sunk.

The graphite mined in the underground workings is on arrival at the surface packed into bags and transported by donkey wagon to Groot Spelonken Siding, and thence by rail to Johannesburg, where the company has a factory in Anderson Street. The factory is equipped with Krupp ball-mills, a water column jig, and other concentrating and washing devices, and a polishing mill for flake graphite. The following products are put on the market: (1) flake graphite, packed in 7 lb. tins and 65 lb. drums; (2) graphite for foundry facings, which is supplied to the South African Railways and all leading foundries in the country; some of the users have found the graphite rather "sticky" for thin castings and mix powdered talc with it; (3) graphite lubricating compound for greasing railway points and tram and railway curves; this is a mixture of finely ground graphite and talc; it is used by the South African Railways and by the Johannesburg, Pretoria, and Durban Municipal Tramways; (4) graphite pipe and flange jointing composition; (5) murella graphite boiler composition for removing boiler scale; (6) lump graphite for use in boilers as a scale preventive; (7) graphite paint. A sample of the amorphous graphite, submitted to J. Faber & Son before the war, was pronounced to be well suited for making pencil leads. The flake graphite appears to be well adapted to the manufacture of graphite crucibles, and, provided that it can be produced in sufficient quantity, there is no reason why graphite crucibles, for which there is a fairly large demand in South Africa, should not be manufactured by one or the other of the Transvaal pottery concerns. The output of the Goedehoop mine from March, 1909, when the company started operations, to the end of October, 1917, amounted to 336½ tons, valued at £11,302. Production at the present time is at the rate of from 8 to 9 tons per month and could easily be increased.

As regards other occurrences in the Transvaal, according to T. G. Trevor there is a bed of impure graphitic shale, up to 7 ft. in thickness, immediately above the Tunnel or Daspoort quartzite horizon of the Transvaal System, as opened up some years ago on the farm Doornhook, to the north of Waterval Boven station, by prospectors in search of coal. It has also been tested on Potloodspruit, adjoining the Lydenburg town lands. A deposit of graphite was opened up some years ago on the farm Groenfontein, in the District of Rustenburg, by the Martyn Graphite Grease Company, but as operations were suspended after a few months it is to be presumed that the occurrence was found to be unworthy of exploitation. On the farm of Witpoortje No. 167, situated about 12 miles north-east of Zeerust, there is an occurrence of a peculiar soft bluish-black rock, consisting of an intimate admixture of talc and graphite. An analysis showed 86% of talc and 10% of graphite, the rest being readily combustible carbonaceous matter. The rock appears to be well adapted to the manufacture of dry lubricants and anti-friction grease. According to the last annual report of the general manager of the South African Railways, a graphite deposit near Derby, in the Rustenburg District, is being tested.

On the farm Doornkloof, 12 miles south-east of Ladysmith, in Natal, there is an interesting occurrence of impure graphite formed by the metamorphism of a thin seam of coal in the Ecca sandstones as a result of the contact action of a sill of dolerite. The material is stated by Dr. Hatch to be too low-grade to be of any commercial value. Graphite in disseminated flakes, thin veins, and small nodular masses connected with the latter occur in the marmorized limestone of Port Shepstone, in Natal. The deposits were opened up some years ago on the Farm Ndongeni, but, according to Dr. Hatch, the work done was insufficient to warrant a definite expression of opinion as to whether or not the graphite-bearing dolomite is worth working. A remarkable occurrence of graphite is described by Dr. Du Toit from the eastern slopes of Ingeli Mountain in Natal. The graphite-bearing rock—altered Ecca shale—which forms a stratum 15 ft. in thickness, consists of pellets of graphitic matter up to one inch and more in diameter, set in a light coloured ground-mass of felspar and micropegmatite enclosing crystals of cordierite and enstatite and flakes of biotite. The graphite pellets, constituting from 6 to 10% of the rock, were found in some instances to be made up entirely of graphite. As a rule, however, they consist of finely divided graphite with colourless interstitial matter from which the graphite cannot be efficiently separated. The occurrence is thus of no economic importance.

Graphite, in bright flakes up to 5 millimetres in diameter and irregular masses, is found in coarsely crystalline marble at Swakopmund, Okanjande, and several other localities in South-West Africa. No attempt has hitherto been made to work the deposits.

According to the preliminary report of the Rhodesia Munitions and Resources Committee (p. 24) several deposits containing graphite are known in Southern Rhodesia, and tests are at present being made on local material with a view to producing flake graphite and graphite anti-friction grease.

POISON GASES IN WARFARE.

The discussion of the use of poison gases in warfare does not come within the scope of mining, metallurgy, or economic geology, but the subject is of interest to all our readers, so we make brief extracts from a lecture delivered at various technical centres in America by Major S. J. M. Auld, a member of the British Military Mission. This lecture is reported in some detail in the *Journal of Industrial and Engineering Chemistry* for April.

The first German gas attack was made in April, 1915. A deserter came into Ypres salient a week before the attack was made, and told the whole story, but no one in the British Army believed him, and no notice was taken of it. That first attack was therefore made against men who were entirely unprepared and absolutely unprotected. The Germans might have won the war then and there if they had foreseen the tremendous effect of the attack. They expected no immediate retaliation, for they had provided no protection for their own men. The method first used by the Germans, and retained ever since, is fairly simple, but requires great preparation beforehand. A hole is dug in the bottom of the trench close underneath the parapet, and a gas cylinder is buried in the hole. It is an ordinary cylinder, like that used for oxygen or hydrogen. It is then covered first with a quilt of moss, containing potassium carbonate solution, and then with sand bags. When the attack is to be made the sand bags and protecting cover are taken off the cylinder, and each cylinder is connected with a lead pipe which is bent over the top of the parapet. A sand bag is laid on the nozzle to prevent the back kick of the outrushing gas from throwing the pipe back into the trench. Favourable conditions are limited practically to wind velocities between 12 and 4 miles an hour. A wind of more than 12 miles an hour disperses the gas cloud very rapidly. An upward current of air is the worst foe of gas. The weight of the gas is not an important factor in carrying it along, for it mixes rapidly with air to form the moving cloud. The most suitable type of country is where the ground slopes gently away from where the gas is being discharged. If a gas attack is to be made with gas clouds, the number of gases available is limited. The gas must be easily compressible, easily made in large quantities, and should be considerably heavier than air. If to this is added the necessity of its being very toxic and of low chemical reactivity, the choice is practically reduced to two gases: chlorine and phosgene. The first attack was made with chlorine. This did not satisfy quite all the requirements, as it is very active chemically and therefore easily absorbed.

In 1915 the British authorities got word that phosgene was to be used. This is a gas which is insidious and difficult to protect against, and a protection had to be found against it. The outcome was a helmet saturated with sodium phenate. This protection proved effective at the time, but provision was made to meet increased concentration of phosgene. There was a long search for materials that would absorb phosgene, as there are few substances that react readily with it. The substance now used very extensively by all is hexamethylenetetramine (urotropine), $(CH_2)_6N_4$, which reacts rapidly with phosgene. Used in conjunction with sodium phenate, it will protect against phosgene at a concentration of 1 : 1000 for a considerable period. An excess of sodium hydroxide is used with the sodium phenate, and a valve is provided in the helmet for the escape of exhaled air. At one period every prisoner taken talked about the use of prussic acid, saying that the Kaiser had decided to end the war and had given permission to use prussic acid.

As regards the future of the gas cloud, it may be looked upon as almost finished. There are so many conditions that have to be fulfilled in connection with it that its use is limited. The case is different with gas shells. The gas shells are the most important of all methods of using gas on the Western Front, and are still in course of development. The enemy started using them soon after the first cloud attack. He began with the celebrated "tear" shells. A concentration of one part in a million of some of these lachrymators makes the eyes water severely. The original tear shells contained almost pure xylyl bromide or benzyl bromide, made by brominating the higher fractions of coal-tar distillates. The Germans started using highly poisonous shells at the Somme in 1916. The substance used was trichloromethyl-chloroformate, but not in great strength. The quantity of gas that can be sent over in shells is small. The average weight in a shell is not more than 6 lb., whereas the German gas cylinders contain 40 lb. of gas. To put over the same amount of gas as with gas clouds, say in five minutes per thousand yards of front, would require a prohibitive number of guns and shells. It becomes necessary to put the shells on definite targets, and this, fortunately, the Germans did not realize at the Somme, although they have found it out since. The use of gas out of a projectile has a number of advantages over its use in a gas cloud. First, it is not so dependent on the wind. Again, the gunners have their ordinary job of shelling, and there is no such elaborate and unwelcome organization to put into the front trenches as is necessary for the cloud. Third, the targets are picked with all the accuracy of artillery fire. Fourth, the gas shells succeed with targets that are not accessible to high explosives or to gas clouds. Take, for instance, a field howitzer dug into a pit with a certain amount of overhead cover for the men, who come in from behind the gun. The men are safe from splinters, and only a direct hit will put the gun out of action. But the gas will go in where the shell would not. It is certain to gas some of the men inside the emplacement. Among the effective materials used by the Germans for gas shells were mono- and trichloromethyl-chloroformate. Prussic acid never appeared; the Germans rate it lower than phosgene in toxicity, and the reports concerning it were obviously meant merely to produce fear and distract the provisions for protection. One substance used for simultaneously harassing and seriously injuring was dichloro-diethyl-sulphide, known as mustard gas. Its use was begun in July of last year at Ypres, and it was largely used again at Nieuport and Armentières. A heavy bombardment of mustard-gas shells of all calibres was put on these towns, as many as 50,000 shells being fired in one night. The effects of mustard gas are those of a super-lachrymator. It has a distinctive smell, rather like garlic than mustard. It has no immediate effect on the eyes, beyond a slight irritation. After several hours the eyes begin to swell and inflame and practically blister, causing intense pain. Direct contact with the spray causes severe blistering of the skin, and the concentrated vapour penetrates through the clothing. The respirators of course do not protect against this blistering.

Up to the present time there has been no material brought out on either side that can be depended on to go through the other fellow's respirator. The casualties are due to surprise or to lack of training in the use of masks. The mask must be put on and adjusted within six seconds, which requires a considerable amount of preliminary training, if it is to be done under field conditions.

Among other surprises on the part of the Germans were phenyl-carbylamine chloride, a lachrymator, and diphenyl-chloro-arsine, or sneezing gas. The latter is mixed in with high explosive shells or with other gas shells, or with shrapnel. It was intended to make a man sneeze so badly that he is not able to keep his mask on. The sneezing gas has, however, not been a very great success. Both sides are busy trying to find something that the others have not used, and both are trying to find a colourless, odourless, and invisible gas that is highly poisonous. It is within the realm of possibilities that the war will be finished in the chemical laboratory.

As regards respirators, it is interesting to note that the French have a fabric mask made in several layers, the inner provided with a nickel salt to stop prussic acid.

The following compounds have been used by the Germans in gas clouds or in shells: Allyl-iso-thiocyanate (allyl mustard oil), C_3H_5NCS (shell); Benzyl bromide, $C_6H_5CH_2Br$ (shell); Bromo-acetone, $CH_2Br.CO.CH_3$ (hand grenades); Bromated methyl-ethyl-ketone (bromo-ketone), $CH_2Br.CO.C_2H_5$ or $CH_3.CO.CHBr.CH_3$ (shell); Dibromo-ketone, $CH_3CO.CHBr.CH_2Br$ (shell); Bromine, Br_2 (hand grenades); Chloro-acetone, $CH_2Cl.CO.CH_3$ (hand grenades); Chlorine, Cl_2 (cloud); Chloromethyl-choroformate (palite), $ClCOOCH_2Cl$ (shell); Nitro-trichloro-methane (chloro-picrin or nitro-chloroform), CCl_3NO_2 (shell); Chlorosulphonic acid, $SO_3.H.Cl$ (hand grenades and smoke pots); Dichloro-diet[illegible] iron, is, (mustard gas), $(CH_2ClCH_2)_2S$ (shell); Dimethyl sulphate, $(CH_3)_2SO_4$ (hand grenades); Diphenyl-chloroarsine, $(C_6H_5)_2AsCl$ (shell); Dichloromethyl ether, $(CH_2Cl)_2O$ (shell); Methyl-chlorosulphonate, CH_3Cl SO_3 (hand grenades); Phenyl-carbylamine chloride, $C_6H_5NCCl_2$ (shell); Phosgene (carbonyl chloride), $COCl_2$ (cloud and shell); Sulphur trioxide, SO_3 (hand grenades and shell); Trichloromethyl-chloroformate (diphosgene, superpalite), $ClCOOCCl_3$ (shell); Xylyl bromide (tolyl bromide), $CH_3C_6H_4CH_2Br$ (shell).

ALTERING A SHAFT FROM RECTANGULAR TO ELLIPTICAL.

At a recent meeting of the Mining Institute of Scotland, Henry Rowan read a paper describing a method of re-lining a shaft with brickwork instead of timber and altering the cross-section from rectangular to elliptical. The shaft is at a coal mine at Cowdenbeath, Fifeshire. It was first sunk 80 years ago, and has been gradually deepened. For the last 40 years it has been 840 ft. deep, and has acted as an upcast. Its dimensions were 16 ft. by 10 ft. inside timbers, but it was not lined with timber all the way. Recently it was found that the timbers required renewal and that the untimbered parts were unsafe, so it was decided to alter the cross-section to elliptical 18½ ft. by 12½ ft. and to line it with brickwork.

The first operation was to select a suitable place for the beams which were to carry what was called the permanent scaffold. When the position for this scaffold had been determined, the length of the shaft to be dealt with was examined and secured, and the work of fixing the scaffold was proceeded with. For this purpose a hanging scaffold measuring about 8 ft. by 8 ft. was used, upon which the men worked until the four beams which were to carry the scaffold were placed in position. Two air-tubes required for preserving the upcast current were then lowered, and rested upon two of the beams; the remaining spaces were covered with 3 in. deals, and a layer of ashes 9 to 10 ft. thick was tipped on to the scaffold and spread all over the shaft. The old fittings of this length of the shaft were removed as far as it was safe to do so, and the work of stripping the sides was begun. While the men were engaged at this work, they used what was known as the bricking scaffold (Fig. 1). The débris was allowed to fall upon the ashes, and the stripping continued to be carried out from this scaffold until the débris was high enough for the men to stand upon. At this point a sole was usually made and a length of brickwork built up. As the brick lining projected into the old shaft at the corners, it had to be bridged across by a curb deal, this being taken out when the next length of brickwork was brought up. When the length of brickwork was finished, a number of deals, 3 to 7, were taken off the bricking scaffold, and *A*, *B*, *C*, *D*, *E*, *F*, *G*, *H*, *I*, *J*, *K*, and *L* (Fig. 2) were put in on either side in order to allow the kettle (Fig. 3) to pass. The débris was then filled out as the remainder of this length was proceeded with. Just above the permanent scaffold another sole was formed, and the brickwork was carried up and joined to the lining overhead. It was found advantageous at times to take a greater length than 40 ft., and in this case an umbrella arrangement had to be fixed between the top of the lift and the top of the tubes, in order to prevent material from falling through the tubes and down the shaft. The length of the lifts of brickwork had also to be varied according to the state of the sides of the shaft.

As the work progressed, it was found that great cavities had been formed at the places where the old lining had given way. These measured from 30 to 40 ft. wide at parts of the old shaft. In cases of this kind the brickwork was carried down to a point as near to the top of the cavity as was safe, and, after securing the sides of the cavity as far as possible, a space about ?against ..'de was sunk from the top of the fall until it reached a position solid enough to form a foundation for the brickwork. A pillar of brickwork 3 to 4 ft. square was then carried up and joined to the upper lining of the shaft. When a similar pillar had been completed on the opposite side of the shaft, work was directed round the periphery of the shaft in short lengths, a space about 4 ft. being cut out and bricked before another was begun, until the whole cavity was enclosed, except for an opening through which the ashes, etc., were tipped for filling up the space behind the brickwork.

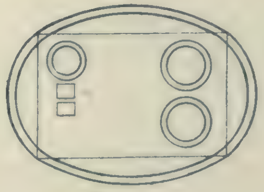


Fig. 1

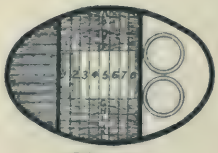


Fig. 2.

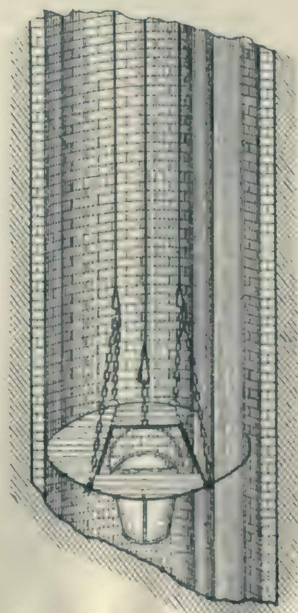


Fig. 3.

After the lining of the shaft was completed, it was fitted with rail-guides weighing 75 lb. per yard fixed to 8 by 6 in. rolled joists at 10 ft. centres. In order to obtain satisfactory results with this class of guide, great care must be exercised in the fitting. In this case the web of the joists was cut out to a depth of 3 in. at each end and the two flanges turned over, thereby making the ends of the joists solid. When this is done, a more rigid bunton is obtained than would be the case if the ends had been left as the makers supplied them. In addition to this, notches were cut in the joists to receive the sole of the guides. The ends of the rail-guides were bored to a depth of 1½ in. to receive a dowel-pin ⅞ in. in diameter, and the soles of the rails were bored for the purpose of fixing a fish-plate on each joint. The guides were built from the bottom upward, the joists or buntons being at 10 ft. centres. There were three joists to each length of guide. The operation was as follows: Three joists were taken down and placed loosely in the holes which had been left in the lining of the shaft for that purpose. The two pairs of guides were then taken down and fastened to the top joist by means of a suspension-block and clamp. The four guides, together with the top joist, were then suspended by a winch, and the remaining two joists were attached to the guides by block and clamp, a clamp being used to bring the lower ends of the rails together. The whole set was then plumbed and the joists built into the brickwork. In taking down the next set of guides, an expansion-piece was bolted to the lower end of each guide, these pieces being removed afterward when fitting the fish-plates to the guides. In this way an equal space for expansion was provided for each length of the guides. The cage-shoes were made of ½ in. plate, two of the plates being shaped to engage the rail-head. The use of a non-rotating winding-rope tends greatly to reduce the wear of the guides and the cage-shoes.

Iron Ore on Raasay Island.—At the meeting of the Iron and Steel Institute held last month, Dr. F. H. Hatch presented a paper on the Jurassic iron ores of Great Britain, relating to which we have given a considerable amount of information recently. In addition to deposits of this class of ore in the Midlands, Lincolnshire, and Yorkshire, there are deposits on the Isle of Raasay, which is situated between the Isle of Skye and the mainland of Scotland. We quote Dr. Hatch's account of this deposit.

A bed of calcareous oolitic ironstone occurs near the base of the Upper Lias in the south of the Isle of Raasay. Its strike is in general north-east and south-west, with a dip of 14° to 15° to the north-west. The formation is cut here and there by north-east and south-west dislocations, causing step-faulting. These faults naturally interfere to some extent with mining operations; but where their throw has been previously determined by boring, the difficulties can be overcome in the lay-out of the mine. Microscopic examination of the unoxidized ore shows that the iron is practically confined to the round oolitic grains, where it occurs largely as a green silicate of iron; while the matrix between the grains consists of carbonate of lime. In the oxidized stone, which occurs where the deposit is covered by less than 12 ft. of overburden, the iron is in the form of hydrated oxide and a portion of the lime matrix has been removed by leaching. On this account this stone is higher in iron and more silicious than the unoxidized ore. A secondary enrichment of the iron is a concomitant of the oxidation process. The thickness of the iron ore bed varies from 5 to 10 ft., averaging about 8 ft. Since a layer of about 1 ft. thickness has to be left on the roof to prevent the overlying shale from breaking away, the working thickness of the ironstone averages 7 ft. The foot-wall is shale. In the major portion of the proved ground the ore-body is overlaid by a considerable thickness of rock necessitating mining. Only over a small area, where there is a slight burden of peat and gravel, is open-cut working possible. Operations are at present confined to one working, access being obtained by an adit, driven in 1,056 ft. from the surface in a north-easterly direction, and rising 1 in 100. The mine is worked to the rise, the distance from the first workings to the outcrop being 1,000 to 1,200 ft. The system of working is by bord-and-pillar, the pillars averaging 40 by 30 ft., with 55 and 45 ft. centres respectively. At present two parallel main roads, 45 ft. apart, serve, the one for haulage and the other for men and ventilation. The endless ropeway is actuated by a motor to which power is electrically transmitted at 2,200 volts from a central station situated near the calcining kilns. At the surface the ore is transported from the mines to the calcining kilns near the pier, a distance of 1¾ miles, by endless rope haulage, the motive power being electrically transmitted. Before passing into the calciners it is sized by breaking and screening. From a hopper at the base of the calciners, the ore is conveyed on a Robins rubber belt to the loading shoot. The capacity of this belt is 500 tons per hour. The pier can accommodate 5,000 ton boats, there being 22 ft. depth of water at low tide. At present 1,000 ton boats are being used, and these can be loaded in two hours. The ore-body has been proved to maintain its value for a distance of two miles along the outcrop; farther north it deteriorates in value and gradually thins out. Beyond the limits of the ground proved by boring, there is no evidence either as to iron-content or as to the thickness of the bed. There can be little doubt that it extends farther in the direction of the dip than has been actually proved. The unoxidized ore from the mine averages about 23% of iron, with lime about 22%, sulphur about 0·6%, and phosphorus 0·9%. It will be seen that Raasay stone is relatively low in iron and rather high in sulphur. As a rule the stone is used in the calcined condition. The high percentage of lime makes it suitable for mixing with the silicious clay-bands of the Scotch coalfield and with tap cinder.

Potash from Alunite.—*Metallurgical and Chemical Engineering* for April 15 gives brief details of the plant and process for extracting sulphate of potash from alunite now at work near Marysville, Utah, producing 20 tons per day of 98% salt. Alunite, the hydrated double sulphate of potassium and aluminium, is a moderately hard, brittle mineral. It is first crushed to about 1 in. size, and is then roasted in a rotary kiln similar to the ordinary cement kiln, having a brick-lined cylinder 7 ft. 6 in. in diameter and 135 ft. long, fired with pulverized coal. The calcined material is leached with hot water in a closed tank at a temperature corresponding to 60 lb. steam pressure, which takes the K_2SO_4 into solution. The larger pieces of insoluble silicious material are unaffected by this digestion, and are removed from the liquor by screening. The solution is mostly filtered in a Kelly filter-press, which removes the fine solids, Al_2O_3 less than 300 mesh, together with a small percentage of silica and iron oxide. The clear filtrate is evaporated in Swenson triple-effect evaporators. The company, the Mineral Products Corporation, will take up the matter of disposal of by-products as soon as the new plant attains its rated capacity of 30 tons of potassium sulphate per day. The alunite is contaminated with a relatively small amount of impurities. The coarse screenings, consisting of silica and aluminium silicates, should make excellent refractories, while the filter-cake, if it can be purified of the small amount of iron and silica it contains, could be converted into aluminium metal or aluminous abrasives.

SHORT NOTICES.

Stone Dusting. — At a meeting of the Manchester Geological and Mining Society held on May 14, A. Rushton read a paper on stone dusting, describing the method of spraying the dust throughout the workings by means of jets of compressed air, thus ensuring that the dust settles on the timbers and ledges near the roof of the workings, where the coal dust accumulates, as well as on the floors.

Kotze's Konimeter.—At the March meeting of the Chemical, Metallurgical, & Mining Society of South Africa, John Innes read a paper on the "Konimeter," an instrument introduced by R. S. Kotze, for estimating the amount of injurious dust in mine air. We hope to give an abstract of this paper in our next issue.

Rheolaveur.—At a meeting of the South Wales Institute of Engineers held on May 24, Professor W. Galloway read a paper describing the "rheolaveur," a washing plant for washing small coal used at collieries in the Lens district, France.

Philippine Gold. — In the *Mining and Scientific Press* for May 4, E. H. Clausen describes lode-mining for gold in the Arorov district, Philippine Islands.

Flotation. — In *Metallurgical and Chemical Engineering* for May 1, A. W. Fahrenwald describes an experimental flotation plant erected at the Texas School of Mines. Mr. Fahrenwald is the author of a book on flotation testing recently noted in our columns.

Flotation of Silver Ores. — In the *Mining and Scientific Press* for April 27, E. J. Atckison describes the treatment at the Amparo mine, Pachuca, of semi-oxidized silver sulphides with sodium sulphide and subsequent flotation.

Flotation.—The annual "milling number" of the *Engineering and Mining Journal*, April 20, contains a number of articles on flotation.

Bibliography of Copper. — In *Metallurgical and Chemical Engineering* for April 15, Paul D. Merica gives a recent bibliography of copper, as an appendix to his articles on the physical properties of copper.

Copper Tuyeres.—At the May meeting of the Iron and Steel Institute, A. K. Reese described the use of copper tuyeres at blast-furnaces.

Molybdenum, Tungsten, and Bismuth. — The *Australian Industrial and Mining Standard* commences with the issue of February a series of articles on the mineralogy, mining, and concentration of the ores of molybdenum, tungsten, and bismuth, and on the chemistry of these metals and their compounds, and the methods of producing the metals and their alloys. The articles will be eventually republished in book form.

Refractories. — A special meeting of the English Ceramic Society was held at Sheffield on May 14, where a number of papers on refractory materials were read.

Radium. — In *Metallurgical and Chemical Engineering* for May 1, R. Cable and H. Schlundt describe their treatment of pitchblende ores occurring in Gilpin County, Colorado. These ores contain a large amount of iron pyrite, and the two minerals cannot be separated by water concentration. The authors treat the ore with gaseous chlorine, and are able to separate the radium chloride from the other metallic chlorides, precipitating it from a solution by adding barium chloride and sulphuric acid.

Determination of Nickel and Cobalt.—At the May meeting of the Iron and Steel Institute, W. R. Schoeller and A. R. Powell presented a paper describing the application of their process for determining cobalt and nickel in ores and alloys to the estimation of these metals in cobalt steel.

Indian Steel.—At the May meeting of the Iron and Steel Institute, Andrew McWilliam presented a paper describing the many metallurgical problems in connection with the production of steel at the Tata works, India.

Genesis of Tungsten Ores. — In the *Geological Magazine* for May, R. H. Rastall commences an article on the genesis of tungsten ores. We shall quote the article when completed.

Salt Domes.—The May *Bulletin* of the American Institute of Mining Engineers contains a paper by E. L. De Golyer discussing the origin of the "salt domes" of Texas and adjoining regions, which contain oil and sulphur, giving a bibliography, and arguing against the theory of volcanic origin.

Oil Shales in the United States. — In the *Mining and Scientific Press* for April 13, Arthur J. Hoskin describes the Colorado oil-shales, and experiments undertaken in connection with their distillation.

Potash Felspars. — The *Journal* of the Society of Glass Technology for May contains a paper by Professor P. G. H. Boswell on the British resources of potash felspar, considered from the point of view of the glass-maker. Workable deposits of this mineral are found in Cornwall, north Scotland, and north-west and south-east Ireland.

Potash in Chile.—In the *Engineering and Mining Journal* for April 13, H. S. Gale and R. C. Wells describe the occurrence of sulphate of potash at Rintados, in the Chile nitrate region.

Power for Oilfields.—At the meeting of the Institution of Petroleum Technologists, held on May 28, J. W. Burford read a paper on the application of electrical power for oilfield purposes.

RECENT PATENTS PUBLISHED.

2,814 of 1917 (114,447). K. SHIGA, Japan. A gold alloy containing nickel and tungsten suitable for use in the manufacture of surgical instruments.

5,062 of 1917 (114,873). NORSK HYDRO-ELEKTRISK KVAELSTOF A.G., Christiania, Norway. Production of a fertilizer by the direct treatment of phosphate rock with nitric acid.

5,549 of 1917 (115,065). R. F. and H. S. POCHIN, Leicester. Machinery for conveying and screening iron ores such as are mined in the Midland Counties.

5,835 of 1917 (115,088). J. S. ROSS and G. L. CRUMP, London. Improved methods of extracting copper from carbonates by leaching with sulphuric acid.

6,245 of 1917 (114,915). J. F. BROWN, Bristol. Improvements in cutters for use in dredges.

6,596 of 1917 (114,407). P. COMMENT, Dijon, France. Improved method of producing anhydrous sulphide of zinc.

7,213 of 1917 (108,850). NORSK AKTIESLSKAT FUR ELEKTROKEMISK INDUSTRI, Christiania, Norway. Method of production of titanium oxide free from iron.

10,435 of 1917 (114,743). E. A. ASHCROFT, London. Method of producing caustic potash from felspars.

11,464 of 1917 (114,953). F. W. HARBORD, London. Improvements in roasting furnaces for the treatment of sulphides of the type in which the roasting hearths are movable and take the sulphides from one end of the furnace to another, the rabbling being done by stationary rabbles.

11,498 of 1917 (112,923). D. B. JONES, Chicago, and C. H. FULTON, St. Louis. Method of producing zinc from blue powder, zinc dross, and ashes.

11,523 of 1917 (109,258). METALS DISINTEGRATING CO., and E. J. HALL, New York. Improved method of grinding metals to powder suitable for the manufacture of paints and explosives.

11,535 of 1917 (114,954). ZELLSTOFF FABRIK WALDHOF, Mannheim, Germany. Improvements in furnaces for roasting sulphides of the type containing a number of vertically superimposed hearths.

13,405 of 1917 (112,008). J. G. GRANBERG, Beckemeyer, Illinois, U.S.A. Improvements in condensers used in re-distilling spelter.

14,286 of 1917 (114,976). A. A. LOCKWOOD, London. In the electrolytic deposition of metals from solutions, conducting the operation under a vacuum of varying extent, thus obviating the need for preliminary clarification, and avoiding polarization.

14,684 of 1917 (115,184). A. L. BLOMFIELD, Denver, U.S.A. Improvements in classifiers.

15,025 of 1917 (114,581). E. F. MORRIS and T. N. C. NEVILL, St. Helens, Lancashire. Improved method of making antimony vermilion.

17,325 of 1917 (115,199). R. KIMBELL, Kettering. Improvements in concentrators.

17,536 of 1917 (114,594). M. H. BAKER, Bendigo, Victoria. Improvements in the methods of mounting Wilfley and Card slime-concentrating tables.

2,223 of 1918 (115,218). W. H. BAXTER, Leeds. Improvements in rock-breaking machines.

NEW BOOKS

Year-Book of Scientific and Learned Societies in the United Kingdom. Cloth, octavo, 340 pages. Price 9s. net. London: Charles Griffin & Co. Ltd.

This is the 35th issue of a year-book which is of very great value to the librarian and bibliographer. Only those accustomed to this class of work can ever have any idea of the great number of learned societies throughout the United Kingdom, or can appreciate the labour and alertness required to keep track of them and their doings. We do not suppose a single reader of this Magazine could give off-hand the names of all the societies in this country before which a paper dealing with some subject relating to mining, metallurgy, or geology might have been read. This year-book gives the required information in this particular circle of studies, and also relating to all other branches of learning; literature, philosophy, natural history, mathematical sciences, chemistry, engineering economics, agriculture, law, medicine, etc. Details of the officers, subscription fees, etc. are given, and also a list of the papers read during each year.

Mineral Enterprise in China. By W. F. Collins. Cloth, octavo, 310 pages. Price 21s. net. London: William Heinemann. A review of this important book will appear in our next issue.

Increasing the Recovery from Oil Sands. By J. O. Lewis. Bulletin No. 148 issued by the United States Bureau of Mines.

Gypsum Products; their preparation and uses. By R. W. Stones. Technical Paper 155 issued by the United States Bureau of Mines.

Concentrating Iron Ores. Bulletin No. 110 of the United States Bureau of Mines, by J. T. Singewald, gives an account of concentration experiments with silicious hematite in the Birmingham district, Alabama.

Hazards at Blast-Furnace Plants. By Frederick H. Willcox. This is Bulletin 140 published by the United States Bureau of Mines, and is a companion to a pamphlet on asphyxiation at blast-furnaces, mentioned in our issue of October last. A great many possible accidents are discussed, and methods of prevention are described.

Technology of Salt-Making in the United States. By W. C. Phalen. This is Bulletin 146 of the United States Bureau of Mines. It describes the various salt deposits in the United States and the method of obtaining salt therefrom. It is a most valuable technological publication.

The Mines Handbook, Vol. XIII. By Walter Harvey Weed. Cloth, octavo, 1,900 pages. Price $10·00. New York: The Author, 29, Broadway.

This book contains information relating to mining companies operating in the United States, Canada, and Mexico, together with some in other parts of the world.

The Oil and Petroleum Manual 1918. By Walter R. Skinner. Cloth, octavo, 240 pages. Price 4s. net. London: W. R. Skinner and *The Financial Times*.

This is the ninth yearly issue of a handbook giving particulars of all the companies known in London producing mineral oil or petroleum. The scheme of the book is similar to that of Skinner's Mining Manual and its reliability and repute are on the same high level.

COMPANY REPORTS

Grenville United Mines.—This company was formed under limited liability laws in 1906 to acquire a tin mine south of Camborne, Cornwall, that had been previously worked for many years on the cost-book plan. Satisfactory profits were made for a time, but the steady decline in the tin content has since led to losses. The report for the half-year ended December 31 last shows that 19,925 tons of ore was raised and treated, yielding 240 tons of tin concentrate, as compared with 21,013 tons and 214 tons during the previous six months. The yield of concentrate per ton was 27·05 lb. as compared with 22·83 lb The accounts show receipts of £33,443 from the sale of 237 tons of concentrate, and a loss of £512. The loss compares with one of £9,954 during the previous half-year. Recent developments have been encouraging, and it is interesting to record that exploration in some of the upper levels is giving good results.

Waihi Gold.—This company was formed in 1887 to acquire gold deposits in the Thames district in the northern island of New Zealand, that had been originally discovered in 1878. The early history of the deposit was not particularly encouraging, and it was not until 1893 that the first dividend was paid. After that year and until 1910 the output and profits were big, and the Waihi was one of the great gold mines of the world. Since then the ore-bodies have been poorer in depth and the amount of ore mined and the yield of gold per ton have both been considerably lower. At the beginning of 1917 development was suspended below the 11th level, owing to the labour supply not being adequate to maintain both the gold output and the development. The report for 1917 shows that 191,742 tons of ore was raised and treated; of this amount 61,627 tons came from the Martha lode, 35,560 tons from the Royal, 35,281 tons from the Empire, 16,075 tons from the Edward, 13,757 tons from the

Regina, the remainder coming from 13 other lodes. The average assay-value of the ore was 33s. 3d. in gold and 3·4 oz. silver per ton, and the yield per ton was 31s. 1d. gold and 2·7 oz. silver. The sales of gold and silver brought an income of £370,566, and the working profit was £193,900, out of which £99,181 was distributed as dividend, being at the rate of 20% free of income tax. The output and returns are much the same as those for the previous five years, and compare with £959,594 and 416,813 tons in the best year, 1909. The total yield of gold since the company started operations has been £11,878,706. Owing to the restriction of development, the reserve shows a decrease of 110,913 tons, standing now at 653,716 tons in general account and 622,680 tons in suspense account.

Waihi Grand Junction.—This company was formed in 1895 to acquire a gold-mining property adjacent to the Waihi in the northern island of New Zealand. The lodes worked are the north-easterly continuations of the Royal and Empire lodes in the Waihi. Milling started in 1906. F. C. Brown, the inventor of the agitator vat for the treatment of slime by cyanide, was the first manager. He was succeeded in 1908 by W. F. Grace, who died eighteen months ago. The report for 1917 shows that 116,130 tons of ore was raised and treated for a yield of gold-silver bullion worth £220,090. After allowance for depreciation and taxes, the net profit was £54,900, out of which £38,437 has been distributed as dividend, being at the rate of 10%. The ore reserve at December 31 was calculated at 131,600 tons, a decrease of 26,100 during the year. This decrease is entirely due to the scarcity of labour. The report giving details of development work done shows generally favourable results.

Golden Horse-Shoe Estates. — This company was formed in 1894 to acquire property at Kalgoorlie, West Australia, and milling commenced in 1899. For eleven years excellent returns were made, but since 1910 the profits have been small and dividends have occasionally been absent. The report for 1917 shows that scarcity of labour and high cost of materials have combined to make it necessary to draw on a larger proportion of the richer parts of the reserve. During the year 176,028 long tons of ore was raised and treated for a yield of gold worth £411,546, being 46s. 10d. per ton. The working cost was £250,684, or 28s. 5d. per ton, and the cost of development was £33,094. After payment of London expenses and taxes, a balance of £100,797 remained, out of which £82,500 has been distributed as dividend, being at the rate of 5½%. J. W. Sutherland, the manager, reports the ore reserve at 748,352 tons averaging 9·58 dwt. per ton, as compared with 709,819 tons averaging 9·5 dwt. the year before.

British Broken Hill. — This company was formed in 1887 to purchase Blocks 15 and 16 from the Broken Hill Proprietary at Broken Hill, New South Wales. The property was not one of the most successful of the silver-lead-zinc mines of the district. The capital was reduced and new funds subscribed on two occasions. Mining operations were twice suspended in the early days owing to the low price of metals. A new ore-body was discovered in 1912, which served to revive the fortunes of the company. On the outbreak of war the mine was closed down. Mining was resumed in January, 1917. During the idle period, the metallurgical plant was reorganized, and the latest practice in flotation methods was introduced. The report for the half-year ended December 31 last shows that 1,761 tons of oxidized ore was raised, averaging 30·8% lead and 6·2 oz. silver per ton, and 70,436 tons of sulphide ore averaging 13·2% lead, 11·3% zinc, and 7·2 oz. silver per ton. At the lead concentrator, the yield of lead concentrate was 11,439 tons averaging 63·4% lead, 7·1% zinc, and 26·3 oz. silver per ton. At the zinc concentrator, 52,242 tons of zinc tailing yielded 9,530 tons of zinc concentrate averaging 45·3% zinc, 8·2% lead, and 10·4 oz. silver per ton. Of the by-products 6,676 tons of slime averaging 6·7% lead, 12·6% zinc, and 6·2 oz. silver was stacked for treatment. The sulphide ore reserve at December 31 was estimated at 1,054,100 tons averaging 13·3% lead, 11·5% zinc, and 6·9 oz. silver. Some carbonate ore is still available in the upper levels, but the amount cannot be estimated. The accounts for the half-year show credits of £254,822, and a profit of £162,298. Out of the profit £39,153 was paid as taxes in England and Australia. The shareholders received £56,250 for the half-year, being at the rate of 3s. per share.

Zinc Corporation. — This company was originally formed to apply flotation methods for producing zinc concentrate from zinc tailing at Broken Hill. Subsequently the South Blocks mine was purchased. Bewick, Moreing & Co. are the general managers, C. G. Hylton is superintendent, and J. A. Agnew is a member of the board. The report for 1917 shows that 134,618 tons of ore was mined and sent to the lead concentrator, averaging 14% lead, 8·5% zinc, and 2·8 oz. silver per ton. There was produced 24,829 tons of lead concentrate averaging 64·4% lead, 6·6% zinc, and 10·2 oz. silver, together with 40,576 tons of zinc tailing averaging 16·6% zinc, 4·7% lead, and 1·9 oz. silver, the remaining 69,213 tons of tailing being worthless residue. At the zinc concentrator, 257,590 tons of zinc tailing and slime was treated, partly material from the company's own mine and partly material from the purchased dumps. The average content was 14·6% zinc, 5·6% lead, and 6·6 oz. silver. From this was obtained 63,700 tons of zinc concentrate, averaging 47·7% zinc, 6·9% lead, and 10·9 oz. silver, 7,164 tons of lead concentrate averaging 56·7% lead, 15·6% zinc, and 30·2 oz. silver, and 7,306 tons of zinc slime averaging 37·2% zinc, 14·1% lead, and 2·6 oz. silver. The deliveries during the year were 32,103 tons of lead concentrate, and 8,432 tons of zinc concentrate. The accounts show a net profit of £225,154, out of which £49,138 has been paid as the 20% dividend on the preference shares, and £179,766 as a dividend of 4s. per share on both the £1 preference shares and the 10s. ordinary shares. The total received on both ordinary and preference shares is thus 40%. The main lode continues to develop well at depth, and the reserve on December 31 showed an increase of 176,369 tons on the year, standing at 1,887,000 tons averaging 14·3% lead, 9·2% zinc, and 2·6 oz. silver. No estimate is made of the ore in the parallel zinc lode, which is not being worked at present. A roasting plant consisting of four Spirlet furnaces has been erected neart he corporation's sulphuric acid plant by the Barrier Roaster Co. for roasting zinc concentrate. The sulphur gases are delivered to the acid plant, and the zinc oxide is sent for treatment for the production of electrolytic zinc by the Electrolytic Co. of Australia. Operations at the mine and works were interfered with by the strike that lasted from August to October. The sale and delivery of zinc concentrate is greatly restricted by the difficulty of shipment overseas.

Kaduna. — This company was formed in 1910 to acquire alluvial tin properties in Nigeria. The first properties to be investigated were in the Kano district, but subsequently properties in the Arim district, 16 miles south-west of Bukeru, were acquired. Production started in 1912. Lake & Currie are the consulting engineers, and J. E. Snelus is manager. The report for the year ended October 31 last shows that

201 tons of tin concentrate was won, as compared with 239 tons the year before and 216 tons the year previously. The sales of concentrate during the year brought an income of £37,482, and the balance of profit was £12,973, out of which £6,942 has been distributed as dividend, being 50%, less income-tax. Practically the whole of the debentures have been converted into shares, the 5s. shares being issued at 15s. The cancellation of the debentures releases funds set aside for redemption, and the issue of the shares at a premium has also added to the reserve fund, which now stands at £13,885, a figure equal to the nominal capital of the company. During the year a considerable amount of prospecting was done, and five new mining leases were acquired.

Lahat Mines.—This company was formed in 1906 to acquire a tin-gravel property at Lahat, in the Kinta valley, Perak, Federated Malay States, and it belongs to the same group as the Tronoh. Three years ago Osborne & Chappel were appointed managers. The report for 1917 shows that 452 tons of tin concentrate was sold, as compared with 438 tons during 1916. The sales brought an income of £59,334, and the net profit was £25,089, out of which £18,000 has been distributed as dividend, being at the rate of 15%. At the new area lately opened, owing to the large amount of clay present, it was found advisable to alter the method of treatment, so a pumping plant was installed.

Consolidated Langlaagte.— This company belongs to the Barnato group, and was formed in 1902 to amalgamate the Crœsus and Langlaagte Star, in the western part of the Central Rand. Deep levels were acquired in 1908. The Crown Reef-Ferreira dyke upthrows the reefs, bringing the southern part 1,100 ft. nearer the surface, so that a new scheme for dealing with this part of the property had to be adopted, and two new shafts were sunk. The mill was rebuilt in 1912, with high-duty heavy stamps. The report for 1917 shows that 588,249 tons of ore was raised, and after the rejection of a small proportion of waste, 585,650 tons averaging 6·05 dwt. per ton was sent to the mill. The yield by amalgamation was 121,714 oz., and by cyanide 49,611 oz., making a total of 171,325 oz., worth £728,945, or 24s. 10d. per ton milled. The working cost was £500,929 or 17s. 1d. per ton. Adding a small profit from the treatment of old slime, the working profit was £228,553, or 7s. 9d. per ton. The shareholders received £166,250, being at the rate of 17½%. The operations were curtailed by a shortage of labour, and the amount of ore raised was 41,400 tons less than in 1916. The developments have for some time disclosed a smaller proportion of payable ore, so it has become necessary to increase the amount of exploration. The cost per ton has increased owing partly to the restricted amount of ore raised and partly to the extra development, and was 1s. higher than in 1916. The reserve at December 31 was estimated at 2,132,778 tons averaging 6 dwt. per ton, as compared with 2,174,536 tons averaging 6·2 dwt. the year before. No sorting is now being done.

Witwatersrand Gold.—This company was formed in 1886 to acquire Knight's property in the eastern Rand. Control passed to the Barnato group shortly before the Boer war. In the early days the results were not good, but since 1905 excellent dividends have been paid. In 1910 the development of the deep level section consisting of a long narrow strip between Knights Deep and Knight Central on the west and Witwatersrand Deep on the east was commenced. The report for 1917 shows that the results have not been so good as formerly, partly because of scarcity of labour and partly because the ore in the deep level section is more difficult to mine, while the development in the part below the dyke has not been entirely satisfactory. During the year, 504,139 tons of ore was raised, and after the removal of 10½% of waste, 451,015 tons averaging 6·1 dwt. per ton was sent to the mill. The yield by amalgamation was 100,677 oz. and by cyanide 31,239 oz., making a total of 131,916 oz., worth £561,268, being 24s. 10d. per ton milled. The working cost was £390,061, or 17s. 4d. per ton, leaving a working profit of £171,207, or 7s. 6d. per ton. The shareholders received £164,368, being at the rate of 35%. The amount of ore treated was 64,885 tons less than in 1916, and the dividend compared with 50%. The ore reserve was estimated at 1,317,900 tons averaging 6·4 dwt., as compared with 1,462,100 tons of the same assay-value at the end of 1916.

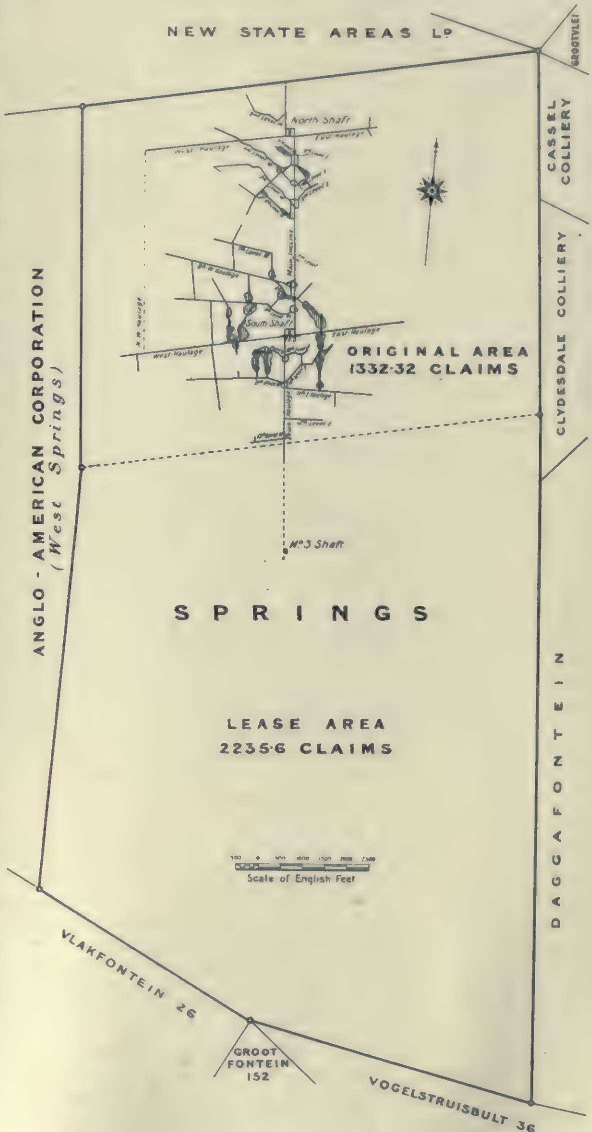
Van Ryn Deep. — This company belongs to the Barnato group and was formed in 1902 as an amalgamation of a company of the same name with the Kleinfontein Deep, in the Far East Rand. Milling started in July, 1913, and the first dividend was paid early the next year. The report for 1917 shows that 654,065 tons was raised, and after the rejection of 20% waste, 517,870 tons, averaging 10·39 dwt. per ton, was sent to the stamps. The yield by amalgamation was 170,858 oz., and by cyanide 94,878 oz., making a total of 265,736 oz., worth £1,129,892, being 43s. 7d. per ton milled. The working cost was £505,901, or 19s. 6d. per ton, leaving a working profit of £623,991, or 24s. 1d. per ton. The shareholders received £508,679, being at the rate of 42½%. As compared with the previous year, the yield per ton was 4s. 2d. higher, the cost 1s. 9d. higher, and the working profit 2s.5d.higher, while the dividend compared with 40%. The policy recently has been to increase the percentage removed by sorting and to mine more ore. Development during 1917 gave excellent results, and the reserve at the end of the year was estimated at 2,258,598 tons averaging 8·9 dwt. as compared with 2,168,851 tons averaging 8·7 dwt. the year before. An additional five stamps and a tube-mill are being erected.

Government Gold Mining Areas (Modderfontein).—This company was formed by the Barnato group in 1910 to acquire a Government mining lease in the Far East Rand, and was in fact the first to acquire a lease on the profit-sharing basis. Milling commenced in October, 1914, with 100 stamps and 10 tube-mills, and this plant was duplicated at the end of 1916. The average assay-value of the ore disclosed has been lower than at most of the other mines in the Far East Rand. The report for the year 1917 shows that 1,408,777 tons of ore was raised, and after the removal of 7·8% waste, 1,298,000 tons averaging 7·3 dwt. per ton was sent to the mill. The yield by amalgamation was 243,924 oz., and by cyanide 210,370 oz., making a total of 454,294 oz. worth £1,930,656, or 29s. 9d. per ton milled. The working cost was £1,236,741, or 19s. 1d. per ton, leaving a working profit of £693,915, or 10s. 8d. per ton. The Government's share of the profit was £230,033, and £175,000 was paid as the first dividend, being at the rate of 12½%. Out of the remaining profit and of the balance of profit from 1916, the sum of £418,777 was written off the account for development prior to production. The working profit for the year was £498,957 higher than that for 1916. The reserve on December 31 was estimated at 7,016,000 tons averaging 7·5 dwt. per ton, being an increase of 2,086,000 tons and 0·3 dwt. over the figures for December 31, 1916. Arrangements are in hand to increase the capacity of the plant to 135,000 tons per month, by the addition of 5 tube-mills and extensions to the slime-filter plant.

Brakpan Mines. — This company belongs to the Consolidated Mines Selection group, and was formed in 1903 to acquire from the Transvaal Coal Trust 881 gold claims on Farm Brakpan No. 16, in the Far East Rand. Milling started in 1911, and the first dividend was for the year 1912. The report for the year 1917 shows that 793,689 tons was raised, and after the rejection of 14½% waste, 677,500 tons averaging 8·49 dwt. per ton was sent to the stamps. The yield of gold by amalgamation was 181,382 oz. and by cyanide 95,355 oz., making a total of 276,737 oz., worth £1,168,454, or 34s. 6d. per ton. The working cost was £686,334, or 20s. 3d. per ton, leaving a working profit of £482,120, or 14s. 3d. per ton. Out of the profit, £90,865 goes to the Government as tax and participation, and £367,525 has been paid as dividend, being at the rate of 47½%. The development during the year covered 13,565 ft. on the reef, of which 7,155 ft. was payable, averaging 13·7 dwt. over 47·7 inches. The ore reserve on December 31 was estimated at 3,268,000 tons averaging 9·2 dwt. over 67 inches, an increase of 214,000 tons at the same average content as compared with the figures the year before. A few blocks of lower-grade ore have been omitted from the estimate owing to the increase in working costs. As already recorded, the company has obtained the Government lease of the remainder of Brakpan farm and of Schapenrust. The two shafts required for the development of this ground have been commenced, but water difficulties have interfered with progress.

Springs Mines. — This company belongs to the Consolidated Mines Selection group, and was formed in 1909 to acquire from the Transvaal Coal Trust 1,160 gold claims forming the north-east part of Farm De Rietfontein No. 4 in the Far East Rand. The banket was cut in the north shaft in March, 1913, at 3,432 ft. and in the south shaft in August, 1913, at 3,692 ft. The milling of mine ore commenced in March, 1917, with 60 stamps and 6 tube-mills. The report for the year 1917 shows that 325,556 tons was raised, and, together with 38,275 tons from the surface dump, sent to the sorting station. After the removal of 13¾% waste, 313,340 tons averaging 10·45 dwt. gold was sent to the mill. The yield of gold by amalgamation was 70,382 oz. and by cyanide 74,725 oz., making a total of 145,107 oz., worth £610,440, or 39s. per ton milled. The working cost was £345,998, or 22s. 1d. per ton, leaving a working profit of £264,442, or 16s. 11d. per ton. During the year 12,658 ft. of development was done on the reef, averaging 16·14 dwt. over 20·17 in. The payable portions measured 6,440 ft. averaging 23 dwt. over 24·9 in. The reserve at December 31 was estimated at 2,567,000 tons, averaging 9·8 dwt. per ton, an increase in tonnage of 783,000 tons as compared with the year before, the average assay-value being the same. Additional metallurgical plant, to raise the monthly output from 30,000 to 40,000 tons, has been completed. We have already given details of the new area to the south recently acquired by the company on Government lease.

Geduld Proprietary Mines.—This company belongs to the Goerz group and was formed in 1899 to acquire gold-mining rights in the Far East Rand. Development was commenced in 1904, and milling started in 1908, but operations were suspended almost immediately owing to water troubles and were not resumed until 1910. The capacity of the plant was extended in 1913 and 1917. The report for 1917 shows that 454,827 tons of ore was mined, and after the rejection of waste, 425,550 tons, averaging 7·44 dwt. per ton, was sent to the mill. The yield by amalgamation was



PLAN OF SPRINGS MINE.

66,216 oz., and by cyanide 82,867 oz., making a total of 149,083 oz., worth £631,364, being 7 dwt. or 29s. 8d. per ton milled. The working cost was £418,526, or 19s. 8d. per ton, leaving a working profit of £212,837, or 10s. per ton. The shareholders received £97,000, the dividend being at the rate of 10%, and £132,665 was placed to capital expenditure account. The ore reserve is estimated at 2,200,000 tons averaging 7·5 dwt., as compared with 2,150,000 tons averaging 7·4 dwt. the year before. The driving of the incline from No. 3 shaft and the intermediate incline from the haulage-way connecting No. 2 and No. 3 shafts is being actively conducted for the purpose of opening up the southern area.

Modderfontein B. Gold Mines.—This company was formed in 1908 by the Rand Mines group to develop property in the Far East Rand adjoining the New Modderfontein to the east. Milling started in 1911, with 80 stamps, and 16 Nissen stamps were added in 1914. Plans have been in hand for some time for a further extension of the metallurgical plant to a capacity of 720,000 tons per year, but the work has been delayed by shortness of labour. The report for the year 1917 shows that scarcity of labour has also interfered slightly with the output, 517,500 tons being milled as compared with 543,700 tons during 1916. The results of this fall and the rise in cost have been compensated by the mining of richer ore. The yield per ton milled was 46s. 2d. as compared with 43s. 2d., the cost per ton 19s. 5d. against 17s. 10d., and the working profit 26s. 9d. against 25s. 4d. The total yield of gold was £1,193,716, the total working cost £502,630, and the total working profit £691,086. Out of the profit £595,000 was paid as dividend, being at the rate of 85%, as compared with £542,500 and 77½% for 1916. Development was curtailed owing to lack of labour, but the reserve was increased by 151,860 tons, now standing at 3,523,810 tons averaging 9·2 dwt. per ton.

Modderfontein Deep Levels.—This company belongs to the Goerz group, and was formed in 1899 to acquire a gold-mining property in the Far East Rand, to the south of New Modderfontein. Shaft-sinking was started in 1910, and milling at the end of 1914. The report shows that 55,836 tons was mined, and after the rejection of 10% waste, 494,659 tons averaging 9·5 dwt. was sent to the mill. The yield of gold by amalgamation was 132,853 oz. and by cyanide 94,826 oz., making a total of 227,679 oz., worth £964,393, or 39s. per ton milled. The working cost was £403,217, or 16s. 4d. per ton, leaving a working profit of £561,176, or 22s. 8d. per ton. The shareholders received £425,000, or 85%, as compared with 67½% for 1916, and 35% for 1915. The yield per ton was 1s. 2d. higher than in 1916, and the cost per ton was the same. The tonnage milled was 40,400 tons more, and the working profit was £76,864 higher. The reserve is estimated at 3,320,000 tons averaging 8·7 dwt. per ton, as compared with the same tonnage averaging 8·4 dwt. per ton the year before.

Village Deep.—This company belongs to the Rand Mines group, and was formed in 1898 to acquire deep-level ground below the Village Main Reef, which itself was a deep level below the Wemmer, Salisbury, and Jubilee, in the Central Rand. The report for 1917 shows that 722,209 tons was raised, and after the rejection of 15% waste, 612,800 tons averaging 7·45 dwt. of gold per ton was sent to the mill. The yield of gold by amalgamation was 150,528 oz. and by cyanide 68,845 tons, making a total of 219,373 oz., worth £914,017, or 29s. 10d. per ton. The working cost was £696,971, or 22s. 9d. per ton, leaving a working profit of £217,046, or 7s. 1d. per ton. The shareholders received £172,359, being at the rate of 16½%. The development disclosed 377,140 tons of ore averaging 6·9 dwt., and in addition 756,000 tons has been opened but not yet valued. The ore reserve is estimated at 1,847,000 tons averaging 6·6 dwt. per ton, as compared with 2,378,000 tons averaging 6·8 dwt. the year before, the fall being due to the large amount of developed ore that is not yet valued. The poor zone on each side of the main incline continues in depth.

Meyer & Charlton. — This company is the most important producer of the Albu group. It was formed in 1888 to acquire a small property in the Central Rand, and in 1909 an additional block on the dip was purchased. The mine has yielded as rich ore as any found on the Rand, and is still continuing to disclose excellent ore in depth. The report for the year 1917 shows that 166,329 tons of ore was raised, and 164,586 tons averaging 16·52 dwt. was sent to the mill. The yield of gold by amalgamation was 58,529 oz., by cyanide 52,162 oz., and from concentrate 1,743 oz., making a total of 112,434 oz., worth £469,415, or 57s. per ton milled. The working cost was £168,043, or 21s. 5d. per ton. The dividends absorbed £220,000, being at the rate of 110%. The reserve at December 31 last was estimated at 493,194 tons averaging 17·66 dwt. per ton, of which 411,010 tons averaging 20 dwt. per ton was in the Main Reef Leader, 39,942 tons averaging 5 dwt. was in the South Reef, and 42,242 tons averaging 6·9 dwt. was in the Main Reef. These figures compare with a total of 512,787 tons averaging 14·5 dwt., and 312,996 tons averaging 20·5 dwt. in the Main Reef Leader, the year before.

City & Suburban.—This company was formed in 1887 under Natal laws to acquire an outcrop property in the Central Rand. Latterly the technical control has been with the Central Mining & Investment Corporation. Excellent dividends have been paid regularly, but the mine is now nearing its end. The report for 1917 shows that 348,767 tons was raised, and after the rejection of 12% waste, 307,141 tons averaging 8·58 dwt. per ton was sent to the mill. The yield by amalgamation was 84,771 oz. and by cyanide 41,186 oz., making a total of 125,957 oz., worth £527,077, or 34s. 4d. per ton milled. The working cost was £367,605, or 24s. per ton, leaving a working profit of £159,471, or 10s. 4d. per ton. The shareholders received £136,000, at the rate of 8s. per £4 share. As compared with the previous year, the yield per ton was 2s. 6d. less, the cost per ton 1s. 8d. higher, the working profit £79,073 less, and the dividend £34,000 less. The ore reserve is estimated at 511,900 tons averaging 7·7 dwt., being a decrease of 90,300 tons and 1·1 dwt. on the year. Development on the Main Reef Leader between the 36th and 38th levels has been disappointing, but in a winze below the 38th level the results have been more encouraging.

New Heriot. — This company was formed in 1887 under Natal laws to acquire a small property on the outcrop in the Central Rand, and the control is in the same hands as the City and Suburban. The report for 1917 shows that 193,520 tons was raised, which, together with 7,130 tons from the dumps, was sent to the sorting station. After the removal of 22% waste, 155,800 tons averaging 8·22 dwt. gold per ton was sent to the stamps. The yield of gold by amalgamation was 42,467 oz., and by cyanide 19,183 oz., making a total of 61,650 oz., worth £256,779, or 32s. 11d. per ton milled. The working cost was £183,509, or 23s. 6d. per ton, leaving a working profit of £73,270, or 9s. 5d. per ton. The dividends absorbed £63,250, being at the of 55%. As compared with the previous year the yield per ton was 2s. 2d. less and the cost 1s. 1d. more, while the working profit was £28,000 less and the rate of dividend compared with 75%. The ore reserve at present available for stoping is estimated at 251,199 tons averaging 7 dwt. per ton, together with 83,778 tons averaging 7·5 dwt. not at present available owing to caving, etc., the total being 334,977 tons averaging 7·14 dwt., a fall of 142,790 tons and 0·46 dwt. as compared with the figures the year before. The property is practically fully developed.

THE CONSOLIDATED MINES SELECTION COMPANY, LTD.

Directors: Walter McDermott (*Chairman*), Robert James Frecheville, Frederick William Green, Louis Oppenheimer, B. Kitzinger and J. S. Wetzlar (*Managing Directors*). *Consulting Engineer:* C. E. Knecht. *Secretary and Head Offices:* C. W. Moore, 5, London Wall Buildings, London, E.C.2. *Johannesburg Branch Office:* The Corner House, Johannesburg; *Managing Director:* F. R. Lynch; *Local Secretary:* J. H. Gratton. *Formed* 1897. *Capital issued:* £552,500, in 1,105,000 shares of 10s. each.

The anuual meeting of the Consolidated Mines Selection Co., Ltd., was held on May 23 at Winchester House, London, E.C., Mr. Walter McDermott (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts for 1917, said: The capital of the company remains unchanged at £552,500 in 10s. shares. Debentures outstanding are £90,460 after allowing for £6,060 drawn for payment on January 1, 1918. Sundry creditors amount to more than last year, and include allowances for income and other taxes in London and Johannesburg. The item of contingent liability requires no explanation, as the character of the company's business involves a varying obligation under this head being taken into account. On the credit side, properties and quoted and unquoted securities aggregate £535,325. 10s. 6d., not including in this £100,000 War Bonds, a slight excess over the corresponding total of the previous year. The valuation of these securities is on the same basis as in the past, that is, they are taken at cost or under; and the total figure would be largely increased if they were valued at market prices of December 31, or at to-day's prices. This appreciation stands as a necessary, but unvalued, reserve, against the risks and fluctuations of such a business as ours. The cash position is stronger at £290,809. 13s. 3d., including War Bonds. A strong cash position is necessary in connection with liabilities the company has incurred for certain guarantees of loans, and for subscriptions for working capital of subsidiary and new companies, to which I will refer later. Sundry debtors are about £9,000 higher than at December, 1916, and are of the usual character incidental to our business, including a large sum for dividends due to us at the end of the year, and since paid. The profit of £164,245. 17s. 4d. compares with £124,003. 10s. 9d. for the preceding year, and the increase is due to a number of successful transactions, and the realization of profits on former investments. You will, however, be interested to hear that the transactions for the year leave us with all our main dividend-paying investments intact, and with new business in hand to replace, satisfactorily we hope, that already realized on; although any benefit therefrom will probably be a deferred one.

The profit of the year, plus the carry over from 1916, gives an available sum of £173,461. 9s. 2d.; and of this it is proposed to transfer £20,000 to reserve account, making this then stand at £80,000, and to pay a dividend of 30%—less income tax—if you approve of a resolution to this effect, which I shall put to you. With these proposals carried, there will be a balance of profit forward of £29,148. 19s. 2d., subject to extra remuneration to directors and managing directors in London and Johannesburg. I think it advisable to say here, that we can hardly expect to repeat this year several of the successful operations of 1917, so that it would be well for you not to consider the dividend recommended to-day as a standard we are expected to live up to for the future. As we have had many lean years in the past, the board recognizes the right of shareholders to a good distribution in a good year.

I will now give some details of some of the business of the past year. At our last meeting I was able to mention the securing of the Brakpan deep-level lease as the most important event; and fortunately on this occasion the directors are able to report an equally important transaction in the securing of an additional lease for the Springs Mines, Limited, which will make that company the owner of mining rights over 3,568 claims. There was competition for this new lease, as there was in the case of the Brakpan ground, but here also our geographical advantages, in having our developments right up to the boundary of the new area, enabled us to offer special inducements to the Government for accepting the Springs Mines, Limited, as partners in the rapid development of the ground. The terms on which Government leases are now granted do not admit of any expectation of exorbitant profits on the part of those who secure them. The calculations of mining chances by the Government engineers, and the influence of the personal equation of the several competitors, ensure that the successful bidder gives fair consideration to the Government. In the case of the new Springs lease, our pioneer position in the Far East Rand, our special knowledge of the immediate district, and our facilities for quick development, all combined to justify a further backing of the mining chances of a continuance of profitable ore area to the south of Springs Mines. Although it is only a few months since the lease was secured, we have been able to extend our main incline from Springs into the new area, a distance of several hundred feet, and this work has shown excellent results in the grade and width of reef. It is, of course, a very small fraction of a very large property, but it is very satisfactory as a start. I have on more than one occasion of our meetings pointed out that the occurrence, and percentage, of profitable ore over any undeveloped area can be only a matter of guess or hope; but with the progress of development at so many different points in the Far East Rand, one can now, with more certainty than in the past, form some idea of the general directions in which Nature has made a generous distribution of the gold values, within the persistent run of the reef. The irregular form of the basin into which the rock strata and included reefs have been bent, gives a great variety to the direction and extent of the dip on different areas, and no fixed relation of these variations to the system of gold distribution has yet been established; but the general effect of all the existing evidence in the district has led the engineers, and the board, to the conclusion that the ground both to the south and west of the original Springs property is so promising as to justify the Springs Mines, Limited, in taking on rather large financial obligations, not only for the absorption of the southern lease, but also for taking an interest in, and affording working facilities to, the new company which has just secured the western lease, to which I shall refer. You will see from the directors' report that the acquirement of the southern lease, with the obligations as to development and equipment of the same, have necessitated a large increase in the capital of the Springs Mines, Ltd., involving an ultimate issue of 500,000 new shares to provide working capital, and to pay off the existing debentures of £314,950. Of the new shares only 200,000 will be issued at present, and the remainder as the requirements of development may call for. As usual in the case of tenders for Government leases, there had to be an absolute guarantee by responsible parties of the shares being taken up, and this financing was arranged by our company in co-operation with the Rand Selection Corporation, the Anglo-American Corporation, and other friends who are always ready to join us in such operations. The authorized capital of Springs Mines, Limited, is now £1,500,000, of which £1,150,000 is issued.

We have a large interest in Springs and should naturally have liked to see an early dividend, and a smaller number of shares issued, after our years of waiting for gold production; but, as with most other Rand mining investments, it is necessary to keep on looking well ahead, and exercise patience, and your directors have considered our future interests as shareholders are best served by the enlarged field of operations, in spite of the obligations involved. There was a substantial working profit from the mill up to December 31 of £258,711. 1s. 1d., and an addition has been made to the crushing capacity, so that we anticipate a very satisfactory return for the current year, unless war conditions should interfere with regular working. The development of the mine last year was fully up to our expectations, and the ore reserve stands at 2,567,000 tons assaying 9·8 dwt. over a stoping width of 58 inches, sufficient for fully 5 years' supply for the present milling capacity. Since December, remarkably good results have been obtained in development; and the directions of discovery of good ore have been such as to offer promise of favourable developments hereafter, in both the southern and the eastern leases. There is one transaction, affecting the value of our large holding in Springs, on which I will say a few words, and that is a participation which the Springs Mines, Limited, has taken in the West Springs, Limited, a new company formed to take over the western Government lease. The tender for this lease was made by the Anglo-American Corporation, with which we are closely connected, and the calculations of the terms offered were based on working facilities to be afforded by Springs Mines, Limited, for a rapid development of the new area through the underground workings of the Springs Mines. As part consideration for the working facilities so granted, Springs Mines, Limited, will receive an option to call for 150,000 shares of the new company, for at least two years, at 22s. 6d. This call will allow of a distribution of one option certificate to Springs Mines shareholders for every ten shares held. The directors of Springs Mines, Ltd., considered the prospects of the West Springs, Ltd., to be good enough to justify their subscribing for 120,000 of the new shares at par; and it is their intention to distribute these shares at the same time, and in the same proportion as, the option certificates, provided no objection to the distribution is raised by the Treasury. The working profit since the mill started enabled the Springs Mines, Limited, to subscribe for this participation in the western venture. The option certificates cost the Springs Mines, Ltd., nothing, except the affording of mining facilities to the West Springs, which assistance will not interfere at all with the proper working of Springs Mines. According to Transvaal financial experience, the option to purchase shares at 22s. 6d. is a valuable one, if over long enough time—as in this case—to offer fair chances of actual mining developments showing what the future prospects of the property are.

The Brakpan mine is in a strong position, with good promise for its continued successful career. The ore reserve of 3,268,000 tons—assaying 9·2 dwt. over 67 inches of stoping width—has been estimated with reference to present higher working costs. For the year under review, the grade of ore milled was 3s. 7d. and costs 1s. per ton higher than in 1916, so that the resulting profit was 2s. 7d. per ton better. Dividends amounting to 47½% were paid for the year. Progress has been made toward the development of the new deep-level lease area, in the starting of two circular shafts to be known as Nos. 3 and 4, which are now down 330 ft. and 223 ft. respectively. The speed of sinking these shafts will be subject to the usual vicissitudes of the district in the matter of water; but late experience has shown that the new system of cement injection can be made of assistance in reducing the difficulties and delays of the past. In the operation of this property, the good results have been secured in spite of the fact that working costs are 3s. 3d. per ton more than under pre-war conditions. During the year some remarkably good and wide blocks of ground have been opened in the south-eastern portion of the mine; and the main incline south is affording good promise for the future, in the direction of the new deep-level lease, although this is still some distance from the bottom of the incline. The profits for the current year should be satisfactory, but there are various war conditions affecting capacity and costs, which will probably prevent the mine giving the full return of which it is capable. As illustrating the effect of present conditions on the gold industry generally, it is noticeable that during 1917 the Rand produced about £37,000,000 and paid £6,500,000 in dividends, whereas in 1914 out of £34,000,000 production £8,000,000 were distributed. Increased cost of supplies, wages and taxes, with special war allowances, have put an extra burden of over £5,000,000 per annum on the mines, and for a number of the low-grade ones there is now no margin of profit to draw on.

Of the Daggafontein mine there is nothing to be said beyond the few remarks in the directors' report. There have been delays in development from one shaft due to water difficulties, not serious in themselves, but inconvenient in view of the present mechanical equipment of the mine, which necessitated the addition of pumping machinery. The latest news from the mine is that water is now under control and development resumed. The development for the year from this shaft was quite promising. The second shaft has also been regarded in its progress by the adoption of the cement process now in use to control the water inflow. Arrangements have been made between the groups chiefly interested in this property for financing its requirements up to early in next year.

The Rand Selection Corporation has shared with us in all important new business, and has benefited with us in the dividend returns on our various joint investments; so that the financial results have been very satisfactory, enabling the payment of 6¼% higher dividend than in the preceding year, while the assets of the corporation would show a large appreciation if valued at the market prices of to-day. I refer you to the directors' report for details of the present position. What I have said as to the Rand Selection Corporation applies, on a smaller scale, to the New Era Consolidated.

Of our interests in properties outside of South Africa, there is nothing important to state. The Burma Corporation is making most gratifying progress, by continued wonderful development of the mine, by increased output in lead and silver, and by organization of the ultimate metallurgical programme for the utilization of the important zinc contents of the ore; but the very scale and character of the undertaking prohibit the expectation of any actual return on our investment here for quite a long period.

The Itabira iron interest is another of the enterprises which we can only regard as a provision for future years. We have increased our interests slightly in this undertaking.

I have not gone into mining details as fully to-day as at some previous annual meetings; but I think the directors' report will have given you all the important points, and I have to take up a little of your time on a question of domestic policy, which has been raised by a circular you have probably all seen, about enemy holdings in our company. I can show you that the premises on which Mr. Kennedy has based his appeal are erroneous, and I think I can also satisfy you that his conclusions do not meet the conditions governing practical politics.

As the circular in question necessarily involves some personal considerations, I should like to say, as an introduction, that I am a bit of a patriot myself, and I should be very pleased to see the enemy holdings distributed by the Public Trustee among purely English shareholders; but, in the conduct of the company's affairs, and when business is in question, I cannot be "more royalist than the King." As a further confession of faith, I will add that I firmly believe the expressions "The Hidden Hand" and "Peaceful Penetration" do cover deliberate schemes, and definite business tendencies, which have been a very serious threat to our national existence in the past, and which must not be ignored in the future as they have been in the past. I can, therefore, approach Mr. Kennedy's circular without hostility; and I will begin by giving him credit for purely patriotic motives, although I know that he wrote a letter to the press two years ago, attacking the company for its unpatriotic composition, and this was a month before his name appeared on our register of shareholders. A hasty criticism might occur to some people, that to join such a company, after exposing its failings, was not a judicious course; but we can assume that the intention of converting the board to a sense of duty necessitated getting a standing within the company itself; and, in any case, the partnership was not to a very incriminating amount.

Taking Mr. Kennedy's figures as given in his circular, I will explain and correct some of these. At present there are actually vested in the Public Trustee 178,886 enemy-owned shares; and 158,359 shares, which, although not vested, are fully controlled by the Board of Trade, as regards receipt of dividends and power of transfer. On our total capital this means 16% vested, and 14% controlled. Of the shares mentioned as being in the names of our managing directors, it might be sufficient for me to say that there should not be any question as to injury to the company in such holdings, as long as their owners are accepted as worthy of being managing directors; but as the mere question of prejudice from German names is here distinctly raised, I must point out that Mr. Kennedy is grossly inaccurate in his statement that 180,000 shares are held by our managing directors, who do not hold one-tenth of that number. When Mr. Kennedy started his crusade, about two years ago, there were, in fact, a very large number of shares standing in the joint names of Messrs. Green and Kitzinger, and Wetzlar and Moore; but Mr. Kennedy, in his zeal, included all these shares, while he omitted any mention of those distinctly English names as joint holders. A large number of the shares in question represented holdings quite unconnected with the personal interests of the two managing directors, and have long since been distributed. From this you will see that the fear of Mr. Kennedy as to your board being in a delicate position, is not well founded, as far as the mere extent of the interests of the managing directors is concerned. As regards the 150,000 shares in names which appear to be German, though their owners live in Great Britain, the Secretary informs me that including those of the managing directors, and speaking with a long experience of German names, there are not over 73,000 shares which can be said to be in such names. Mr. Kennedy is, therefore, inaccurate in this matter, but, in any case, it is impossible for your directors to go into the complicated question of the peaceful penetration of German names in this country; and, under English law, they have neither power, nor means, to do so. The only real charge, therefore, which we have to meet is the existence of the large enemy holdings, now under Government control: "the very head and front of our offending hath this extent, no more." I am able to say, in the language of Parliament, that this matter has received our serious consideration, and long before Mr. Kennedy's exhortation. The idea of buying all the enemy holdings is not a novel one; several people have had it under consideration. If some individual, or group, merely bought the shares for some business purpose, we might be free of the "Hidden Hand," and take the ordinary business chances of seeing later any cloven hoof. From all I can learn, the Public Trustee is a hard-headed business man, without any outward and visible sign of possessing a heart to appeal to, and with a fixed habit of selling to the highest bidder when he does realize on any securities once in his hands, granted that nationality is correct. Mr. Kennedy says that your directors can call on the Board of Trade to vest in the Public Trustee all shares held by enemy aliens—which would be the 159,359 shares not already vested—and having done this, we can press for their realization, provided we have a mandate from our shareholders, as a shield for the board against "the wrath of the large pro-German influence still believed to exist in financial circles." Mr. Kennedy is evidently unaware of the fact that more than one attempt has been made in this direction, by asking the Public Custodian if he would sell the shares; and the reply was in the negative. We had also received the advice of our solicitor (in answer to inquiries made of us) that there were not sufficient grounds for pursuing the matter. If we should see such change of policy on the part of the Public Trustee as would improve the prospect of getting the enemy holdings of shares distributed among English shareholders, you may be sure of the active sympathy of the board in its execution.

Mr. Kennedy does not stop at a reformation of our own company; he proposes to ask us to take efficient steps immediately about the enemy holdings in all our subsidiary companies, in which we hold shares. Now those subsidiary companies are all African ones, under Transvaal law, and, moreover, all their enemy holdings have long ago been vested in the Custodian of Enemy Property in the Union of South Africa. We cannot exercise any useful pressure on the African Public Trustee to the advantage of our shareholders. Before leaving this subject, I feel bound to express my opinion that the body of our shareholders cannot in reason agree to anything in the nature of a reflection on the association with our two managing directors, after accepting their services without question during the whole period of the war, and after absorbing uncomplainingly the dividends, to the earning of which these directors have largely contributed. They have been, I believe, loyal, naturalized British subjects for many years. We may sympathize with the personal suffering of Mr. Kennedy in the matter of enemy holdings, but we must remember that it has not been of long duration; that it was self-inflicted; and that it is easily curable, without pecuniary loss.

In the conduct of our affairs for the last two years we have had valuable financial aid from our co-operation with the Anglo-American Corporation of South Africa, of which Mr. E. Oppenheimer is chairman. Mr. Oppenheimer acted for our company in the negotiations which led to the securing of the Brakpan lease, and also the southern Springs Mines, but in the case of the western Springs lease, he acted on behalf of the Anglo-American Corporation, under arrangements with us by which we secure the technical management of the new West Springs, Limited. I have on this occasion to express again the indebtedness of the board to Mr. Oppenheimer for his services.

In conclusion I must offer our thanks to our managing director and our consulting engineer in Africa, and to the managers of our subsidiary companies and to their staffs generally, for the good work done and for the success achieved. Our London staff, under the able direction of Mr. Moore, have been worked very hard, and we owe him and them thanks for all that has been accomplished while very short-handed.

Mr. R. J. Frecheville seconded the motion.

Mr. S. S. Kennedy moved an amendment giving instructions to the directors from the shareholders to take all the steps in their power to get the remainder of the shares vested in the Public Trustee, and that they should use every endeavour to get the shares sold and, when sold, that they should be offered to the whole of the remaining shareholders in this company pro rata to their interest. His object in desiring that the shares should be offered pro rata was that a large block of some 350,000 shares should not simply go out of the hands of the enemy alien into the hands of someone else who, although he might be a friend today, might not always see eye to eye with the directors, who, he quite admitted, had acted so well in all the financial and technical arrangements of the company, which had given such excellent results. Up to now the Chairman had failed to convince the Public Trustee that he ought to sell the holdings referred to, but he (the speaker) maintained that if the directors could go to the Board of Trade and show that they had a resolution of the shareholders behind them and that the wish of the shareholders was that the enemy alien holdings should be removed absolutely from the share register, it would be the duty of that department to make such an order as would vest those shares in the Public Trustee, whose duty it would be to sell them in due course.

Mr. George List seconded the amendment.

Mr. Alfred Hicks said he happened to know a little about the Public Trustee, and there was no harm in his informing the meeting that he had twice offered to buy the whole of the shares in question from that official, who, however, had refused the offer. He had made a firm offer to the Public Trustee for the total holding, and that official's reply was, as representing the Government of this country, that it was not proposed to deal with such holding. He agreed with the Chairman that the Public Trustee knew his business quite well, and he believed there were reasons why the Government and the Public Trustee did not like to deal with such blocks of shares. He hoped the meeting would negative the amendment because the present directors had been controlling this company for many years, and if after the speech which the Chairman had made as to the way the directors were dealing with the situation the amendment should be passed it must be regarded as a vote of censure upon them. An agitation of this kind could do the company no good and very often led to distrust and dissatisfaction. It would be a great pity to do anything which would impair the success of the company, which always adopted an honourable attitude in all its negotiations and enjoyed a very high reputation in the financial world—a reputation which was due as much to the managing directors as it was to the whole board.

The Chairman said he did not think the excuse which Mr. Kennedy had given for issuing his circular was sufficient, because it was issued under circumstances which gave the directors no chance whatever of correcting his mistakes. Mr. Kennedy had had two years in which to correct those mistakes, but had not taken the opportunity of doing so, and he had made statements on the strength of which it would be very easy to get proxies, and he had got proxies. He had made out a very touching case so as to enable the directors to show their independence, which they really wanted to show, but were afraid of showing. He (the Chairman), however, had disposed of that, and Mr. Kennedy now admitted that he was wrong in regard to the essential elements of the number of shares which still had an influence, or might have an influence, on the policy of the board. He could safely say that, as far as the large number of enemy holdings was concerned, no director could want to have a more quiet and peaceable set of men than those enemy shareholders had been. They had had no influence whatever on the directors. He had sympathy with the remarks which Mr. Kennedy had made; no one could take objection to them on the broad principle that he thought the directors had not done enough, and there were means by which they might do more, and that as an expression of general sympathy it would be well to back them up by a resolution of the shareholders. However, he (the Chairman) considered the amendment in the light of a vote of censure, because he had already shown that the directors did not require this assistance. He thought they must put it to the test as to whether the shareholders as a body thought that the directors required this particular piece of "ginger" which Mr. Kennedy was offering.

After some further observations, Mr. Kennedy withdrew his amendment, and the motion for the adoption of the report and accounts was carried unanimously.

ANGLO-CONTINENTAL MINES COMPANY, LIMITED.

Directors: W. F. Turner (*Chairman*), Edmund Davis, E. W. Janson, Hetherington White. *Secretary*: A. W. Berry. *Office*: 22, Austin Friars, London, E.C.2. *Formed* 1909. *Capital issued*: £155,000 in 10s. shares.

Business: Operates tin properties in Nigeria; holds interests in the Abbontiakoon, Mongu, Mount Oxide, Trinidad Leaseholds, and other companies.

The annual general meeting of the Anglo-Continental Mines Co., Ltd., was held on May 23, at Winchester House, London, E.C., Mr. W. F. Turner (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts for 1917, said: A year ago I said that we hoped that this year we might be able to hold our general meeting in the month of April. That has not been possible, as the accounts from Nigeria did not arrive as early as we expected. The consequence is that this meeting is being held only about a week earlier than last year's, and we must take it that while present conditions continue our annual general meeting cannot be held until the latter part of the month of May. The report which is in your hands states in a condensed form the results of the past year, and together with the balance sheet, shows how matters stood at December 31 last, and I shall not need to say a great deal in elaborating them. I concluded my address at the last meeting by saying that we looked forward to the end of the year with a good deal of confidence, and, as you will have seen, that confidence has been justified. The profit and loss account shows a considerable increase in earnings, the amount for the year being, in round figures, £33,000, as against £15,000 for the preceding year. The expenses show a slight increase, as is only to be expected in these times, and there will probably be a further slight increase for the current year. I have explained on previous occasions that, while our expenses look large on paper, they are not so in the result, and that, when our earnings from secretarial work are placed against them, the net cost is very small indeed. There is a new item in the profit and loss account this time, losses written off £3,434. This consists of about half a dozen items, relating almost entirely to matters of old standing. Such losses are bound to occur from time to time in a business like ours, though for some years past we have been tolerably free from them. I may mention incidentally that in writing off these losses we get rid also of a contingent liability of about £3,500 which has been hanging over our heads for a long time past, and you will see from the balance sheet that our contingent liabilities at December 31 amounted to the trifling sum of £240. After writing off these losses, there remains a balance of £29,643 to the credit of the account, including the balance brought forward from last time, which is carried to the balance sheet.

We propose to declare to-day a dividend of 15% free of income tax. This will require £23,250, and will leave £6,393 to be carried forward to the next account. The position, therefore, is that a year ago we declared a dividend of 7½% and carried forward £5,391, while this time we declare a dividend of 15% and carry forward almost exactly £1,000 more. The next paragraph in the report states that no provision has been required for depreciation of the company's investments, which, on balance, show an increase in value. I shall come to this point again in dealing with the balance sheet.

Now as regards our operations in Nigeria during the past year. The output of tin concentrate was 271 tons against an estimate of 300 tons, and we have taken up during the year a considerable number of Mining Rights, some on the Gora river and its tributaries and some on our Murchison property, covering in all a length of about 21,000 yards, but no new areas have been taken up. The year has been one of considerable difficulty, involving a good deal of work and worry, the reflection of which is contained in that passage in the report which states that a complete rearrangement of the company's management was effected which, it is believed, will prove advantageous to the working for the current year. From the nature of the case I cannot go into this matter in any detail. I do not want to reflect unduly on anybody concerned, and the matters in question are not such as can be satisfactorily discussed with any advantage in public. I told you last year that our profits from Nigeria in the year 1916 were very small, and while the average price of tin for the year 1917 showed a considerable improvement, our profits were not such as might have been expected from the output which was obtained. The change of management took place only after nine months of the year had elapsed, and in the end it involved a change of the entire mining staff. This, of course, created a good deal of difficulty for the new management during the three months which remained of the year, nor have the difficulties as yet altogether passed away. We consider that we have got a greatly improved and efficient staff, and we are confident that the working of our properties will be more successful during the current year than it has been for some considerable time past. We have to bear in mind, however, in justice both to the late and present management, that as time goes on in working these alluvial and surface deposits the tin becomes more difficult to win at a profit. That is the general experience in Nigeria and elsewhere. On the other hand, we hope that by vigorous prospecting of our properties further discoveries will be made which will enable the output to be maintained on something like its present scale, and with due care in regard to working expenses we should obtain satisfactory results not altogether dependent on the present price of tin. I have been speaking of the prospecting of the properties we already hold, but we have made special arrangements for prospecting outside these properties. There cannot be any certainty in such a matter, but we anticipate that in due time our expenditure will be justified and that we shall be able to make additions to our properties.

The next paragraph of the report refers to the Mongu Company, which continues to prosper. That company paid a balance dividend of 10%, free of income tax, in June, 1917, and an interim dividend of 10%, less income tax, in November, 1917. The company will be holding its annual general meeting within the next few weeks, when a thoroughly satisfactory state of affairs will, I am sure, be disclosed. At the last meeting I went in some detail into the position of the Mount Oxide Mines and the Mount Elliott Company. We still hold our share interest intact. There have been difficulties in regard to the company's plant, and this and other causes have necessitated the making of certain financial arrangements. These difficulties we understand have been surmounted. The plant is running satisfactorily, the monthly output of copper is increasing; and by the coming autumn the company should have discharged the temporary liabilities which it has had to incur. Nothing has happened to alter our opinion of the intrinsic merits of the concern, and we count upon this asset proving a very remunerative one in the future. We also retain the whole of our investment in Trinidad Leaseholds, Limited. That company has undergone a very considerable development during the past year. It has absorbed another company which was operating in the same region, and the output has now reached the substantial figure of 14,000 tons per month. The company has liquidated its liabilities, and there seems to be a good prospect of its commencing the payment of dividends by the end of the present year, when our patience will be rewarded, as it has been already in the increased price of the shares. We also retain and have somewhat increased our interest in Ropp Tin, Limited. This, as you know, is already the largest producer of tin concentrate in Nigeria. It has erected two large dredges, which are now running and are reported to be in perfect working order. It has been a long and costly enterprise, but there is every reason to believe that it will be fully justified by the results, and that there will be a large increase in the dividends paid by the company.

There is very little to be said about the balance sheet, which it will be admitted is a satisfactory one. The creditors amount to £4,560, which is about half of what they were in the preceding balance sheet. At the present time our liabilities are almost nil. The cash at bankers, the Treasury Bills and the War Loan amounted together to £58,264, which is a very good proportion out of a share capital of £155,000. The debtors are much the same as last year. As regards the investments, £119,110, these are taken at cost. There have been, of course, fluctuations in value. Some of them are higher and some lower than in the preceding balance sheet, but, on balance, there is an increase in value. They show a substantial margin over cost and looking at them all round I think it is safe to say that they should show a further increase in value in course of the present year. As regards the prospects of the current year, these are on the whole satisfactory, and we hope that when the time comes the results for the year will be found to be at least equal to those of the year which is past.

Mr. Edmund Davis seconded the resolution, which was carried unanimously.

The Chairman proposed the re-election of the retiring director, Mr. Hetherington White. The motion was seconded by Mr. E. W. Janson, and carried unanimously.

A vote of thanks to the Chairman, directors, and staff in Nigeria was proposed by Mr. Weston and carried by acclamation.

WAIHI GRAND JUNCTION GOLD CO., LTD.

Directors: H. D. Bishopp *(Chairman)*, Major G. H. Earle, Stanlake Lee, H. J. Rothwell, T. H. Hamer. *Secretary:* S. Leah. *Office:* 10, Throgmorton Avenue, London, E.C.2. *Formed* 1895. *Capital* £400,000,

Business: Operates a gold mine in the northern island of New Zealand.

The ordinary general meeting of the Waihi Grand Junction Gold Company, Ltd., was held on May 29 at Salisbury House, London, E.C., Mr. H. D. Bishopp (Chairman of the company), presiding.

The Chairman, in moving the adoption of the report and accounts for 1917, said that the tonnage treated showed a reduction of 9,650 tons, but in consequence of the slightly improved grade of ore, the return was only £3,488 down. The total revenue was £220,039, or only £476 below that of the previous year. The net profit was £54,900, an increase of £5,104. On the balance sheet the additions to plant, machinery and buildings was only £2,386, while the depreciation written off was £13,320, the total being down £10,934 to £125,613. Mines development account was reduced to £61,409. The £60,000 Four-and-a-Half per Cent. War Loan had been converted into Five per Cent. stock, and a further £40,000 had been acquired, raising the total to £100,000, costing £94,249. They had also taken up £40,000 of the National War Bonds, redeemable in 1927. Treasury bills, cash on deposit and cash in hand at £52,061 showed a reduction of £23,461. They had within the last month applied to the New Zealand Government for £10,000 of their Four-and-a-Half per Cent. Loan at par; the loan was free from local income tax. The general reserve fund remained at £30,000. An interim dividend of 5%, free of tax, was paid in November last, and the directors recommended a final dividend of 5%, free of tax, making 10% for the year. There would remain a balance of £36,479, which the directors recommended be carried forward. That the shortage of labour was having a serious effect on the returns might be seen by comparing the results of milling operations to April 20, 1918, with those to April 21, 1917, the reduction in quantity of ore treated being nearly 9,000 tons and in value of bullion obtained over £17,000. Development was necessarily almost at a standstill, and they would have to face a further reduction in ore reserves unless conditions materially improved during the coming months. In the early years of the company's existence there was a difference with their neighbours with regard to the mine water. The dispute was settled by an agreement in 1905, which subsisted until 1912, when a new agreement was entered into. This agreement was terminable after 1915 by either party giving six months' notice, and in February of last year they received such notice, determining the agreement in the following August. They then pointed out that, unless some new agreement were arrived at, there would be a danger of constant disputes. Certain proposals made at the time by their neighbours they considered did not afford a basis for agreement, and the matter was still unsettled. In view of the intention to extend materially the development of the mine so soon as the termination of the war rendered labour conditions more favourable, they had engaged Mr. James T. Dixon to visit the property and advise on both the water question and development.

The report and accounts were adopted unanimously.

MOUNT BOPPY GOLD MINING CO., LTD.

Directors : Sydney F. Hoffnung-Goldsmid (*Chairman*), B. J. Leverson, Vere H. Smith, Robert Taylor, Edgar Taylor. *Consulting Engineers and Managers :* John Taylor & Sons. *Secretary :* W. F. Garland. *Office :* 6, Queen Street Place, London, E.C.4. *Formed* 1899. *Capital :* £121,000 in ordinary shares, and £30,000 in 10% cumulative preference shares, both of £1 each.

Business : Operates a gold mine in Cobar district, New South Wales.

The nineteenth ordinary general meeting of the Mount Boppy Gold Mining Co., Ltd., was held at the offices of the company, 6, Queen Street Place, London, E.C., on May 22. Mr. Sydney F. Hoffnung-Goldsmid (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts for 1917, said that a year ago the directors had considered the time appropriate for sinking a new shaft, which was, for various reasons, imperative. They had to come to the decision, impelled by adverse circumstances, to temporarily stop work at the mine, and they took advantage of this decision to sink the new shaft. That shaft had been sunk and completed. It was commenced on May 18 of last year, and completed to the required depth of 400 ft. early in January of this year. Many thousands of tons of oxide ore in the vicinity of the old main (Taylor's) shaft would now be available for extraction. The stoping costs of this would be light, as the ore was to be underhand stoped. This method of stoping would effect a material reduction in the cost of timber, which since the beginning of the war had more than doubled in price. The new shaft had been sunk at a convenient site to the east of the existing workings, and communications between the shaft and the old workings had been effected. This work was carried out concurrently with the necessary re-arrangement of the surface plant. This re-arrangement, together with a saving in the tramming costs and road upkeep, were estimated to show a reduction of several pence per ton of ore milled.

This important operation could only be undertaken at a large outlay of capital. The cash resources of the company were equal to the strain. Milling operations were begun again at the end of January. Stoping had been commenced at the new open-cut, and at various levels. Other sections of lode would soon be available. It was satisfactory to know that the original estimate made of the cost of sinking the shaft, of the re-arrangement of the surface plant, and of the current expenses of the company during the period of the cessation of work, had not been greatly exceeded. Much of the credit for this was due to easier labour conditions. The directors had a year ago decided to close down the mine for the time being, in view of the growing shortage of labour and other adverse conditions. That they had now thought it in the best interests of the company to recommence operations was proof that the reorganization and the expenditure incurred was fully justified. It was estimated that the ore reserves at December, 1916, amounted to 154,813 tons. The amount taken out of the mine during January and February—the last two months prior to the cessation of work—amounted to 5,479 tons. No developments were undertaken during 1917, so that the reserves at the end of 1917 were reduced by this extraction to 149,334 tons. To this could now be added at least 100,000 tons of ore rendered workable by the conversion of Taylor's shaft into an ore pass, and by the sinking of the new shaft and the necessary underground connections associated with it, so that the ore reserves to-day might be estimated as amounting to at least 249,334 tons; an amount that without reckoning future developments would give to the mine, under favourable conditions, a further life of at least 3½ years. They had made a fair commencement, and when they got back to normal conditions, there was no reason why they should not be able to begin to accumulate profits and to resume the payment of dividends. The return for February of this year was 1,934 oz., for March 1,495 oz., and for April 2,240, total, 5,369 oz., of an estimated value of £15,085. The gold produced in 1917 realized £8,920, the plant only working during January and part of February. The revenue expenditure, including a sum of £3,691 extended on repairs to buildings, machinery, and plant, amounted to £20,114. There was, therefore, a balance of £10,070 to be carried to the debit of profit and loss account. In view of the exceptional position at the mine during the past year, the directors decided to write back to profit and loss account £12,500 of the £15,000 placed to reserve fund in 1914. As regards the prospects, the superintendent reported as follows: "The present year opens under more favourable conditions than have obtained for a long time. Active operations have been resumed. The new plant is giving satisfaction, and the results, so far achieved, have come up to expectations, with a prospect of an early return to normal conditions. These favourable features, taken in conjunction with the now available reserve of milling ore, render the outlook decidedly hopeful." He desired to give expression to the appreciation of the board of the services rendered to the company by their superintendent at the mine, Mr. Negus, who had remained unremittingly at his post during the time the new scheme was being carried out, though his leave of absence was due.

Mr. Robert Taylor seconded the motion.

Mr. Edgar Taylor said that as a result of the new scheme, they had now many thousands of tons of oxide ore rendered available for milling in the vicinity of Taylor's shaft, which formerly could not be mined to advantage, but which could now be extracted by a open-cut system of stoping, at a greatly reduced cost and with minimum of labour. The returns from the mine since resumption of operations had been:

In February,	5,161	tons averaging	6½	dwt. bar gold.
,, March,	6,439	,,	4⅔	,, ,,
,, April,	6,448	,,	6$\frac{9}{10}$	,, ,,

It would be noted that the grade of this ore was low, and this was accounted for by the fact that in commencing to stope the open-cut a great width had to be taken away, and as a result the ore sent to the mill was of lower grade than they expected to mill when they got to a depth of, say, 100 ft. To the ore reserves, estimated at December 31 last at 149,334 tons, might now be added at least 100,000 tons of oxide ore rendered available under the new scheme, bringing the total reserve to close upon 250,000 tons at the time of re-commencing milling.

The resolution was carried unanimously.

THE RHODESIA BROKEN HILL DEVELOPMENT CO., LTD.

Directors: Edmund Davis (*Chairman*), Sir E. H. Dunning, Cromwell Hockley, Alexander Stewart, H. L. Stokes, Lord Teynham, Lt.-Col. C. H. Villiers. *Consulting Engineers:* Hooper, Speak & Co. *Secretary:* T. Donald. *Office:* Salisbury House, London, E.C.2. *Formed* 1904. *Capital issued:* £172,770. 15s. in shares of 5s. each.

Business: Operates a lead-zinc deposit in Northern Rhodesia, and produces metallic lead.

The adjourned annual general meeting for 1917 and the annual general meeting for 1918 of the Rhodesia Broken Hill Development Co., Ltd., were held on May 27, at Salisbury House, London, E.C., Mr. Edmund Davis (Chairman of the company) presiding.

The Chairman said that on December 31 last the ordinary general meeting, at which the accounts to August, 31, 1917, should have been submitted, was adjourned to a date to be fixed, and in accordance with promise, the board also submitted the balance sheet to December 31, 1917, and to meet the convenience of those present one statement would be made to cover the two meetings. In future the accounts would be made up to December 31, so as to hold the annual meeting earlier in the year. At August 31, 1917, the cost of machinery, plant, buildings, &c., which were taken over by the Rhodesian Lead and Zinc Syndicate, Ltd., was added to general development, together with expenditure incurred between the date of the commencement of the lease, April 1, 1916, and the time the syndicate actually took over, November 9, 1916. Under the agreement the syndicate had to repay the amounts which had been borrowed from other parties —namely, £26,309—which had therefore been deducted, the result being that at December 31, 1917, there was a sum of £39,016 to the debit of general development account. The only other point arising out of the accounts was the issue of shares, 50,000 having been allotted prior to August 31, in accordance with the consent of the Treasury, and since that date 120,000 had been paid for in full options of 180,000 exercised, although these had not yet been allotted. They were in their infancy, it being only on June 21, 1917, that a small experimental furnace was put out of commission and one new furnace blown in on the 25th of the same month, and a second on October 18, 1917. Their proposition was being well equipped, and an extensive system of tramways had been laid down connecting the mine, which was half a mile from the smelters, with the storage beds, works, and railway, also for bringing in the wood fuel for the boilers, and traction engines had been acquired to cope with increased transport, and stocks of wood and coke had been accumulated for future requirements. New offices had to be built near the works, and the old offices, three-quarters of a mile distant, were converted into men's quarters. The syndicate's lease commenced on April 1, 1916, and to the end of December last 18,480 tons of ore had been smelted for a yield of 4,780 tons of lead. Since December 31 and up to the end of April last, 3,471 additional tons had been produced, an average of 868 tons per month, against an estimated average production of about 900 per month, which reflected credit on their consulting engineers, Messrs. Hooper, Speak and Co. In view of the capacity of the plant it had been necessary to do a considerable amount of work to open up large ore reserves. The smelting ore mined was won from No. 1 kopje, and in the course of mining large quantities of zinc ore and mixed lead and zinc ore had been separated and dumped for future treatment, and approximately 20,000 tons of overburden containing lead and zinc values were also broken and dumped. In the course of prospecting two bodies of high-grade lead ore had been met with to the east of No. 1 kopje, but owing to the want of pumping machinery exploration had been confined to above the water level, and only the caps of the mineral bodies had so far been touched. Their manager was of opinion that there was every indication of large bodies of lead ore existing below, and that both these bodies might be found in depth to form one large deposit with No. 1 kopje. These discoveries affected the question of continuous production with the present plant. Outside of these lead and zinc deposits they also had what might possibly develop into a very large zinc producer in the deposit known as No. 2 kopje which was estimated to contain to water level about 300,000 to 320,000 tons of 32% zinc ore.

Developments tended to prove that the proposition might be a larger concern than ever contemplated, but additional capital must be provided for equipment and development. In connection with capital, some time back they obtained Treasury consent to the issue of 50,000 shares to provide part of the capital required, and they made arrangements to issue 120,000 additional shares referred to on the debit side of the balance sheet at December 31, 1917, having received the £30,000 due on the same. It would be necessary to issue the whole of the reserve shares, and it was satisfactory to report that the calls on 180,000 had been exercised, subject to the Treasury's consent to the issue, but to date they had met with nothing but refusals from the committee on fresh issues of capital to the various applications they had made, though they were face to face with a financial position which must be dealt with. The plant was being worked to its utmost capacity, and nearly the whole of the output was being supplied to the Ministry of Munitions, which, in view of the national importance of the enterprise, had kindly supported their application for permission to issue additional capital.

At the meeting on December 31 reference was made to arrangements with the Central Mining and Investment Corporation, Ltd., to despatch some members of their staff to carry out certain work on the property with a view to their interesting themselves financially in the company. Their engineers advised the sinking of a series of bore-holes, and the data secured from No. 1 bore-hole, and given in the report, were not only interesting, but most encouraging, showing there was a large body of ore containing lead and zinc values. A few days ago a cablegram was received giving results of No. 2 bore-hole. The information was immediately sent to the press,: "Second bore-hole started near edge of kopje at same point as last bore-hole, but at flatter angle, calculated to reach centre of kopje at vertical depth of 150 ft. First 40 ft. drilled in dolomite, then 22 ft. in oxidized zinc ore, then 77 ft. of high-grade lead ore (mostly oxidized), to total depth 139 ft. Hole proceeding in ore."

The Chairman concluded by moving that the accounts for the year ended August 31, 1917, be approved and adopted.

Mr. Alexander Stewart seconded the motion, and it was carried unanimously.

BRITISH BROKEN HILL PROPRIETARY CO., LTD.

Directors: J. S. Smith-Winby *(Chairman)*, F. S. Saunders, Alexander Stewart, W. H. Woodhead, W. J. Magarey, J. K. Samuel, F. V. Sanderson. *Secretary:* T. Mullett. *Consulting Engineer:* G. C. Klug. *General Manager:* C. J. Emery. *Office:* Salisbury House, London, E.C.2. *Formed* 1887. *Capital:* £339,000.

Business: Operates the British lead-zinc-silver mine at Broken Hill, New South Wales.

The thirty-eighth ordinary general meeting of the British Broken Hill Proprietary Company, Ltd., was held on June 5 at Salisbury House, London, E.C., Mr. J. S. Smith-Winby (the Chairman) presiding.

The Chairman, in moving the adoption of the report and accounts for 1917, said that their mine was in full activity, and their entire production had been sold, including the stocks in hand at December 31 last. The mill restarted on January 31 last year and continued without interruption until August, when one of those unfortunate and inexplicable strikes broke out to which even in war time they seemed to be always liable at Broken Hill, and they had to shut down for a couple of months. In a recent communication from Adelaide their colleagues there took pride in calling attention to the output and mining costs in comparison with other mines on Broken Hill. For the first time in their history they had during the second half of the year the biggest output of all the Broken Hill mines, and the mining cost figures, though naturally a good deal higher than in normal times, had been kept down as much as the present rate of wages and prices of mining requisites would permit, and, all things considered, could be favourably compared with those published by their neighbours. For the first half of last year the accounts showed a profit, after providing for administration expenses and depreciation, of £40,533 (subject to taxes) and for the second half-year £93,678 (also subject to taxes) or a total for the year of £134,211, from which, however, they were obliged to set aside for income tax and war taxes under various denominations, payable in Great Britain and Australia, no less a sum than £39,154. This amount was a heavy imposition, but they and other Anglo-Colonial companies were suffering from the fact that, as the law of this country at present stood, they were called upon to pay double income tax. They must continue to protest against this real injustice to all Anglo-Colonial companies.

As regards Australian zinc, the whole of the Australian producing mines had joined together to have their output sold through the single channel of the Zinc Producers' Association. For some time past negotiations on behalf of the association had been proceeding with the Imperial Government. These negotiations were initiated by Mr. Hughes when he was in London and Mr. Bonar Law was at the Colonial Office, and had been followed up and carried through with conspicuous ability by Mr. W. S. Robinson on behalf of the board of the association. Mr. Robinson had acquired a complete mastery of this most complicated question and had expounded it to the Government representatives in all its bearings, both technical and commercial, in so lucid and convincing a fashion as to provoke the admiration both of the directors of the association and also of the not easily excited Board of Trade officials. In discharging these laborious duties Mr. Robinson, as time would prove, had performed a considerable public service. The outcome of the negotiations was a contract recently made between the President of the Board of Trade and the Zinc Producers' Association for the purchase by the Imperial Government of the stocks of Australian zinc concentrates existing on December 31, 1917, less certain reserves and also of the entire production from January 1, 1918, for the period of the war and ten years thereafter, subject to certain reservations to cover existing contracts and the requirements of Australian works, including the electrolytic works recently founded in Tasmania.

Their position as regards zinc concentrates was appreciably improved, and as regards the leadies, these, including the carbonate ores, were treated and realized by the Broken Hill Associated Smelters' Company, in which they were shareholders. The mine and mills had been maintained in good order. They were also proposing to rebuild their offices at the mine, new offices having been badly wanted for some years, and, further, to erect half-a-dozen more cottages for the housing of some of the officials. The buildings would, it was estimated, cost approximately £10,000. The balance sheet showed that the financial position had greatly improved as compared with this time last year. At the end of 1917 the liquid net assets amounted to £165,131, as against £78,436 in the previous year, or an increase of nearly £90,000, and since the end of last year they had been considerably augmented by the receipt of proceeds from realization of products taken into the balance sheet at cost. The accounts were presented in their usual clear and simple form. The important item was the amount of the profit, which he had already said was £134,211, subject to income tax and war taxes. Adding the net result to the balance standing to the credit of the profit and loss account, they arrived at a total of £69,787, after deducting the interim dividend distributed in January last and providing for the taxes. The directors were able now to recommend the payment of a final and free of tax dividend for the year 1917 of 2s. per share, which would absorb £37,500 and leave a balance of £42,287 to carry forward to the next account. In respect of the current year's operations they proposed to declare an interim dividend of 2s. per share, also free of tax, which would make a total distribution of 4s. per share that would be paid on July 2 to the shareholders registered on the books on this date. They felt that in making this distribution, which, without deduction for taxes, was equivalent to about 5s. 6d. per share, they might possibly be accused of opening their purse-strings rather widely, but bearing in mind that they were suffering from enforced idleness for so long a period, during which the shareholders, while getting no return from their investment, accepted the situation with great patience and with a confidence that was highly appreciated by the board, they thought that they were reasonably warranted in now making a distribution that they hoped the shareholders would consider satisfactory, especially as it might assist some of them in increasing their personal holdings of National War Bonds, to which it was so vitally important every one of them should subscribe, be the individual contribution ever so small, down to the last shilling they could spare

Mr. Franklin S. Saunders seconded the motion, which was carried unanimously.

BISICHI TIN MINING COMPANY (NIGERIA), LTD.

Directors: James Gardiner *(Chairman)*, William Graham, W. S. Coutts. *General Manager:* A. W. Hooke. *Secretary:* H. J. Barrow. *Office:* 33, Cornhill, London, E.C.3. *Formed* 1910. *Capital:* £200,000.
Business: Operates an alluvial tin property in Northern Nigeria.

The seventh annual general meeting of the Bisichi Tin Company (Nigeria), Ltd., was held on June 10 at Cannon Street Hotel, London, E.C., Mr. James Gardiner (the Chairman) presiding.

The Chairman, in moving the adoption of the report and accounts for 1917, said that the output for the year under review showed a marked decrease. This was due partly to difficulties caused by the abnormal conditions created by the continuance of the war, and the consequent Government legislation in regard to restrictions on provision of material, supply of tonnage, and recruitment of labour; partly also to the necessity for a revision of the position in Nigeria in view of providing for further development work in anticipation of the current year's operations. As a compensatory factor they had had a considerable advance in price, which had enabled them to obtain a result which, on the whole, did not compare unfavourably with the realizations of the previous year. A year ago the price was £236. 12s. 6d., while the attitude of the Government to the producers could hardly be considered benevolent, and they were discouraged from the belief that it was an essential metal. The entry of the Americans into the war and the consequent mobilization of their industries engaged in the production of munitions gave an added impetus to demand, and the introduction of the license system speedily revealed the fact that supply was barely, if at all, sufficient for all requirements. From the beginning of October a steady advance in price set in, and the record was made at £380 a month ago. Since then there had been a decline, the price on the last market day (Friday) being £330. As the result of these conditions their ore, which averaged 71·09% of metallic contents realized an average price of £194. 12s. 2d. per ton, as against £136. 5s. 2d. in the previous year. It would be futile to prophesy as to the further course of the market, and they could only hope that, in view of the certainty of increased costs and charges, the price might be maintained. The net realizations of ore at December 31, 1917, were £61.353 as compared with £35,207 at the same date of the previous year. Their tin came home much better last year; they had a lot hung up in 1916.

With the outlook as at present, after nearly four years of war conditions, their position was eminently satisfactory. On the occasion when he last addressed shareholders he made appreciative mention of the policy of Messrs. Elder Dempster in regard to freight, but very shortly a material change in the situation took place. Their fleet of steamers was taken under control by the Government and as a consequence the rate on ore was immediately advanced 90%. This was an instructive example of State intervention in trade. No change had been made in the scale of royalty, but as this was on a percentage basis, the advance in price of the metal had increased pro rata the payments they had to make. There had also been no alteration of the Nigerian railway schedule during the year, but some change was foreshadowed in a Colonial notification on the subject, although he could not yet say whether their ore would in any way be affected. During the twelve months under review they had had to pay a high rate of insurance for war risk on shipments, and they had had cause in that period to formulate claims for total loss on three occasions. As regards the other factors affecting the costs of working, native labour had been obtainable in fair supply, but the material had been chiefly raw and untrained and had therefore been less efficient, while it had required closer supervision, thereby entailing extra strain on the European staff. The health of the Europeans had been good, and there had therefore been no extra tax on their capacities from that cause. The work had been carried on under strenuous conditions, and their thanks were due to the manager and his staff for their loyal co-operation in the interests of the company.

During the year a considerable amount of work had been carried out not only in the course of current operations, but in preparation for those of 1918, in spite of the adverse circumstances which had prevailed by reason of the restrictions on export of material, tools, and supplies. Pipeline spares, etc., ordered from the makers in May of 1916 and delivered by them in December, 1916, were only allowed to be shipped in February, 1918. It said much for the initiative and energy of Mr. Hooke, their general manager, and his assistants that, despite these drawbacks, the efficient working of the pipeline, etc., was maintained. The much-needed spares had now, he hoped, arrived on the property. They had made arrangements for supplies of tools direct to Nigeria from America, which would do away with any cause for anxiety in that connection.

The total of gold excavated was 260,315 cubic yards, as against 143,293 in 1916, and while working out most of the old paddocks five new paddocks had been opened disclosing satisfactory deposits. The general policy followed had been to work the lower grade ground in combination with the richer positions, and the advance in price of tin had added to the profitable results on treating the former. Although no additions had been made under the head of "Mining leases," four mining rights had been secured over ground contiguous to the company's property at the head of the Fusa stream, and a fifth had been applied for with a certainty that the application would be granted. Jointly with the Forum River Company they had acquired an exclusive prospecting license over 3¾ square miles in the Bukeru district. On all of these there were favourable indications of the presence of payable deposits, and prospecting would be undertaken as circumstances permitted.

Mr. W. S. Coutts seconded the resolution, which was carried unanimously.

Mr. Graham moved the re-election of Mr. James Gardiner, the retiring director. He remarked that Mr. Gardiner had been a director of the company since its formation, and he was sure that he had in every way won the confidence of the shareholdors. Speaking himself as a director, he could say without hesitation that Mr. Gardiner was a most valuable asset to the company. His heart and interest were in the company; he devoted a large amount of time, attention and intelligence to its affairs; he was a very large shareholder in the company, and, therefore, his interests were those of the shareholders generally.

Mr. Coutts seconded the motion, which was carried unanimously, and the Chairman thanked the shareholders for the renewal of their confidence.

ZINC CORPORATION, LIMITED.

Directors: F. A. Govett (*Chairman and Managing Director*), J. A. Agnew, H. W. Pelham Clinton, R. W. Skipwith, P. Lyttelton Gell, W. C. C. Romaine, Tyndale White. *Local Board in Melbourne:* T. B. Birkbeck, W. M. Hyndman. *General Managers:* Bewick, Moreing & Co. *Superintendent:* C. G. Hylton. *Secretary:* T. E. Smith. *Office:* 20, Copthall Avenue, London, E.C.2. *Formed* 1911. *Capital issued:* 653,139 ordinary shares of 10s. each, and 245,692 preference shares of £1 each.

Business: Operates the South Blocks mine at Broken Hill, and treats zinciferous tailing for the extraction of zinc concentrate by the flotation method.

The seventh ordinary general meeting of the Zinc Corporation, Ltd., was held on June 7 at River Plate House, London, E.C., Mr. F. A. Govett (Chairman and Managing Director) presiding.

The Chairman, in moving the adoption of the report and accounts for 1917, said that the growth of the company's mine since the time when he bought a half-interest in the South Blocks for the Lake View had been colossal. When the South Blocks Company was amalgamated with the corporation, the reserves had grown to nearly 550,000 tons, and in the seven years which had since elapsed they had reached a figure not out of sight of 2,000,000 tons, after the extraction of 1,000,000 tons during this period, while the grade was practically the same. The feature of the recent past was the development of the bulge or replacement body at the north end of the mine, which was really part of the main lode, though generally separated from it by barren country. It extended from below the fifth level to the lowest point now being developed, No. 9 level, where the width was as much as 140 ft., with approximately normal values. It was an enormous body, and no reason existed to suppose that it did not extend to greater depth. During this year they would start on No. 10 level. On No. 8 level at No. 5 shaft they cross-cut the zinc lode, showing 20 ft. in width with 19% zinc, or a higher value than on the level above, and a bore from the main lode further north, 475 ft. south of the main shaft, showed the zinc lode channel to be 125 ft. wide. In this channel they passed two sections, the first 30 ft. wide worth 21·2% zinc and the second 35 ft. wide worth 20·6% zinc. This was more than satisfactory, indicating the soundness of the idea on which the amalgamation was made, namely, the provision of zinc ore in anticipation of the exhaustion of the purchased dumps which formed the original basis on which the corporation was created. This, however, was less important than it was formerly owing to the development of their great lead mine. The mine and plant, for reasons beyond the control of the management, were shut down for a period, but for which the profits of the year would have been much larger. No new great development had occurred in treatment, but good progress had been made. They now had not only the electrolytic process but also the chloride process, which was approaching finality of proof, and two other processes, one invented by the Elmores here and the other in Australia. Serious trials were being made, and these processes would have to work out their comparative advantages, but he believed that one or the other—perhaps more than one—would have an important bearing on the profits of the industry. If successful the chloride promised best, for it made a good extraction of the silver and produced all the metals in a condition ready for established metallurgical processes. No doubt before next year there would be more definite progress to report.

The question of the formation of a company to erect zinc smelters in England had not yet matured, and beyond the expansion of existing works and progress with the erection of works at Avonmouth nothing had been done. He had previously pointed out how essential it was that this country should produce at least its own requirements for war munitions and the vital importance of their not being again dependent for any munition of war on other nations; but there was no immediate hurry, for smelters could not be erected to provide spelter for this war, and that after its termination the exhaustion of the world would be such that any further war for a considerable period was at least improbable. The wisdom of this conclusion was confirmed by the position of shipping. Material could not now be shipped at all. Already some existing works were not in full operation for want of material, and probably this condition would continue for some time after the war. An entirely new consideration arose, namely, whether from the point of view simply of war munitions the smelters would not be better in the colonies rather than in England, in view of the risk of loss by submarines and the less space required to ship metal instead of concentrates. A second new factor was the further call on man-power, which would make erection far more lengthy and difficult, if not impossible. Adding the developments in the metallurgy of these metals, which, though still unproved, were nearer proof, he felt that it was a matter of congratulation that they had feared to tread and had not dashed in. Even omitting what would become the dominating point of doubt—post-war working costs and supplies of material like coal—it must be considered that, with the dislocation of normal industry under war conditions, the demand for spelter now was less, except for munitions, certainly in America since her entry into the war. He had previously spoken of the enormous expansion of her works and output. The result was that 40% of the retorts were now shut down, with a stock of about 70,000 tons, and the price of spelter in America under £35 per ton, while here the cost of production was probably £50 per ton. The cost would not stay there, and it was impossible to predict the post-war figure; and it looked as if America would be able to produce much cheaper. He was a whole-hog protectionist, but there must be some limit to the protection a nation could give, and he doubted whether the British Government would be brave enough to tackle any large disparity in the cost of production in this country and outside until time had established the normal disparity.

When they made their first contract with the Government for zinc concentrates they were negotiating for the erection of spelter works in England with Government support. He had always been anxious that the corporation should share therein, and had the other Broken Hill companies decided that sufficiently good terms could be arranged, no doubt they would now be committed to the work, though he hoped his point would not have remained unmet—that the present was not the proper time for erection, on the grounds already stated—that erection could not be in time for this war, there was no need of hurry for the next war, while the cost would be double the normal, so that the profit would have to be twice as great to make any reasonable return on the money invested. In August, 1914, Mr. Hoover and he approached the Board of Trade with the first suggestion that the Government should subsidize the erection of national zinc works. That suggestion had since been adopted. He was not anxious to see the corporation's resources used in building and running works, but they were always ready to take part in any joint national or imperial scheme with the other Broken Hill companies provided the decision when to erect should be postponed until war obscurity had passed away. While it was vital that the production of spelter should be at least sufficient for the munitions need of any future war, in no case was there anv reason to consider increase of output beyond the commercial requirements of the Empire. In 1915 they formed a small deputation to Mr. Bonar Law, headed by Mr. Hughes, to make a definite offer to erect smelters in England or Australia, subject to businesslike conditions. This deputation led to the first contract with the Government, now commuted for the present contract. The existence of this contract, however, did not absolve them from the obligation to stick to their guns, and, subject to the other Broken Hill companies taking their share at the proper time, the corporation would be ready to join in any reasonable Government scheme for the erection of smelters in England, or possibly in Australia, not in the hope of large profits, but, if it were justified by moderate and reasonably certain profits, to enlarge, duly protected in some way, within the Empire the spelter industry of which they produced the raw material. This question of the erection of smelters was only shelved, and probably not for long, for those engaged in the galvanizing and brass industries of this country must view the outlook with much apprehension, unless there were some promise of big smelters working here or elsewhere within the Empire. The vast expansion of the output of brass manufactures in America and Japan seriously threatened British manufactures in the post-war trade, and the same was true of galvanizing.

Under the stimulus of war the scope of the corporation's business had expanded, and its growth would have to be continued on proper lines in assisting subsidiary industries dependent on or allied to the metals which the corporation produced. In 1914 they were just a mining company. They were now interested in the production of fine spelter by the Electrolytic, of lead and its derivatives, of spelter and zinc dust in the Associated Smelters. They were producers of silver and, with others, of sulphuric acid. They must not shrink from their responsibility to expand, and he thought that upon them rested the responsibility to utilize their organization and resources in this way, certainly in view of their domicile in Australia. But this was limited to industries dependent on or associated with their own. It was in this way that they would foster the demand within the Empire for the raw materials which primarily it was their duty to produce. As to the zinc end of the business, the company's contract of 1916 with the Government for 100,000 tons a year had now been cancelled and a new contract made by which the Government took, with certain limitations, the whole output of Broken Hill during the war and for ten years afterwards. The precise terms and details of the contract it was not necessary or advisable to discuss, in view of their close relations with the Imperial Government, but he would say that it gave the company some certain profit, and that the terms were eminently fair. In the same way as they had shown their sincere desire not to take advantage of the necessities of the Government in their stress for lead, it had been the board's endeavour and wish in this matter to be reasonable and fair, and without hesitation he could say that the terms were fair.

Passing to the company's financial position and the balance sheet, the total value of their interests, including the mine and the Associated Smelters and their interest in the Electrolytic was put down at £324,000. As a matter of fact, at the present time the other interests, without the mine, could be fairly valued at that figure, but the mine was a wasting asset, and the two subsidiarv companies—the Associated Smelters and the Electrolytic Zinc—were likely to be of the same character, unless further lead and zinc deposits could be found to take the place of Broken Hill when the mines were at last worked out. But now, and for a long time ahead, the position of the property account was extremely strong, for the mine must now be worth somewhere about another million. Big mines died very hard, and this was a big mine; but they did die at last, and it was his ambition by that time to have piled up sufficient reserves to provide not only the money for the return of 20s. upon the £1 preference shares, but also for the return of the same amount upon the ordinary shares, in view of the fact that they were £1 shares before they were cut down in the reorganization of the company. To pay the preference would take £245,000, so that at present it looked as if they were well started toward that goal. But the point remained of the wasting nature of some of the items in that £324,000, while in the other interests there was some depreciation with which they ought to deal, in spite of the fact that the total figure was largely exceeded by the present value of the assets. This company paid for its shares in the Associated Smelters out of profits, and in that way it was written off; but the cost of the Electrolytic had to be provided out of the tailings-redemption fund, and during the ensuing years this should be replaced and written off as a wasting asset. The expenditure on various processes was undertaken solely with the object of improving their metallurgical work, or the economical production of materials which they used. Some of this would be, without doubt, directly valuable, while there must be failures, but such expenditure was absolutely necessary. The Electrolytic was of a rather different nature, and was too large to treat this way, but none the less the cost should be redeemed, as they could afford, over a series of years, and the board proposed to transfer to reserve the sum of £15,000 to form the nucleus of a redemption fund for that purpose. No doubt in this company they would have to subscribe further, possibly up to £100,000 or more, for it looked as if it would certainly again be expanded from its present capacity of 10 tons a day to 100 tons, as soon as they got the full complement of electric power, for lack of which they had been somewhat hampered in their operations. As for the company's interest in the Barrier South, he was trying to arrange some settlement of its unsatisfactory position, but so far he had not been able to do so. That interest was taken as the deep level of their mine, but with the growth of their mines and the better prospect of the zinc lode this now had not so much importance as it had, and, frankly, he would far rather have their money than the property itself. However, it might still turn out to be valuable in the far distant future. He was glad to say that after this long delay there was some chance of the sulphur process being developed, for it was under the consideration of an important European company. As to their unfortunate Granville holding, this matter had at last got into better shape, for he thought that all chance of litigation was now at an end. Though he believed that most, if not all, of the money would come back, he did not feel that he could see it any longer in the list of their interests without writing it down to something like its present valuation, which he regarded as 75% for the prior lien and 20% for the first mortgage, the shares having cost this company nothing. This would require, say £16,000, which would make a total depreciation of about £36,000. The directors proposed — in spite of the large excess of the present values of the holdings in the investment account, owing to the inclusion of £100,000 Associated Smelters, which had been already written off—to apply the balance remaining after the payment of the dividend in writing off half of that amount, £18,000, from the investment list, and to carry to reserve a sum of £15,000 to form the nucleus of a fund to replace the money invested in the Electrolytic, in case it might turn out to be a wasting asset and not the establishment of a permanent industry. Out of the profits of the current year, which promised to be at least as large as those of the past year, they could complete the cleaning up of the balance sheet and add something to the nucleus of that fund.

With regard to the probabilities of future profits, he would strictly limit any forecast to the current year, for the major portion of their profits came from lead, and at present the company's output was sold only until the end of this year, beyond which the only certainty was the Eastern and Australian trade, the profit on the sales of zinc concentrates under the recent contract with the Government, and some outside contracts with Japan. The necessities of the lead consumers seemed to demand the prolongation of the lead contract in some shape or form and this, he thought, was practically unanswerable. Disregarding the cost of freight, the price of lead was not likely to be low, for the demand would be large and the supply short, while their zinc concentrates were already sold at a remunerative price. Anyway, for the current year it seemed as if the profits of last year should be at least maintained, unless they were again shut down for want of labour, or on account of labour trouble.

Mr. Tyndale White seconded the motion, which was carried unanimously.

The Chairman then proposed "That a dividend of 2s. 6d. per share, less income tax, upon both preference and ordinary shares of the company's capital be, and is hereby, declared, payable on October 1, 1918, being the final dividend out of the surplus profits of the company in respect of the year ended December 31, 1917, and that the transfer books of the company be closed for one day—namely, August 20, 1918."

Mr. H. W. Pelham Clinton seconded the resolution, which was carried unanimously.

OURO PRETO GOLD MINES OF BRAZIL, LTD.

Directors: John Taylor *(Chairman)*, Edwin Beer, Marcel Paisant, E. de Wael, Robert Taylor. *Honorary Director:* Baron Oberkampt. *Managers:* John Taylor & Sons. *Secretary:* G. H. Wells. *Office:* 6, Queen Street Place, London, E.C.4. *Formed* 1884. *Capital issued:* £12,212 in preference shares and £39,429 in ordinary shares, both of £1 each.

The fourth ordinary general meeting of the Ouro Preto Gold Mines of Brazil, Ltd., was held at 6, Queen Street Place, London, E.C., on June 11, Mr. John Taylor (Chairman of the company) presiding.

The Chairman, in moving the adoption of the report and accounts, said that during the year under review 82,500 tons of ore were milled, producing 28,840 oz. of bar gold, equal to a yield of £1. 7s. 11¾d. per ton, which showed the slight improvement of 3½d. per ton over that of the previous year. On the other hand, the ordinary costs in Brazil came out at £1. 6s. 5¼d., an increase of 10¼d. per ton, which was accounted for by the enhanced prices ruling for all mining requirements, the smaller tonnage milled, and the higher rate of exchange, which averaged 12⅜d. against 12 3/16d. He might say he was agreeably surprised that the increase in costs was not greater, in view of all the adverse circumstances under which they had laboured. The amount realized by the sale of the gold was £115,432, and in addition £1,293 was received for interest, rents, etc., the gross income reaching £116,725. The total expenditure on revenue account aggregated £111,891, and a profit was shown of £4,834, which compared with some £7,240 for the previous year. It was not possible with any degree of certainty to forecast the results which might be expected in 1918. Labour, which during the past 3 years or so had been fairly plentiful, had recently become scarce, and they had not been able to keep up the monthly tonnage to the full capacity of the mills. All mining stores, in common with almost every other commodity, were constantly rising in price, and they were feeling the effects of that to a serious extent. In those circumstances they could hardly look for any decided improvement in their returns of gold in the immediate future, although he could assure shareholders that every step possible to counteract the increase in costs was being taken by their energetic superintendent, Mr. Arthur J. Bensusan.

Mr. E. de Wael seconded the resolution.

Mr. Robert Taylor then addressed the meeting, dealing more particularly with the underground operations. The total extraction by mill and cyanide process, he said, showed a slight improvement, 92·3% as against 92·13%, and practically the same proportion of sands and slimes was cyanided as in the previous year. At the last meeting it was stated that the scale of development would have to be reduced, owing to the necessity for curtailing expenses at a time of high rate of exchange, and also owing to the difficulty of obtaining suitable men without depleting the work in the stopes. As a consequence, the year's work in development amounted to 1,100 metres (3,609 ft.), compared with the excellent record obtained during 1916 of 1,650 metres (5,411 ft.).

The report and accounts were unanimously adopted, and the retiring directors and auditors were re-elected.